**U.S. DEPARTMENT OF COMMERCE**
**National Technical Information Service**

PB-290 921

# Regional Air Pollution Study Point Source Methodology and Emission Inventory

**Rockwell International, Creve Coeur, MO Air Monitoring Center**

**Prepared for**

**Environmental Sciences Research Lab, Research Triangle Park, NC**

Jul 78

United States
Environmental Protection
Agency

Environmental Sciences Research
Laboratory
Research Triangle Park NC 27711

EPA-600/4-78-042
July 1978

Research and Development

PB 290921

EPA

# Regional Air Pollution Study

## Point Source Methodology and Emission Inventory

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NATIONAL TECHNICAL
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U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

## TECHNICAL REPORT DATA

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| | | |
|---|---|---|
| 1. REPORT NO.<br>EPA-600/4-78-042 | 2. | 3. RECIPIENT'S ACCESSION NO.<br>PB290921 |
| 4. TITLE AND SUBTITLE<br>REGIONAL AIR POLLUTION STUDY<br>Point Source Methodology and Emission Inventory | | 5. REPORT DATE<br>July 1978<br>6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S)<br>F.E. Littman | | 8. PERFORMING ORGANIZATION REPORT NO. |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Rochwell International<br>Air Monitoring Center<br>11640 Administration Drive<br>Creve Coeur, MO 63141 | | 10. PROGRAM ELEMENT NO.<br>1AA603 AA-07 (FY-77)<br>11. CONTRACT/GRANT NO.<br>68-02-2093<br>Task Order 108A |
| 12. SPONSORING AGENCY NAME AND ADDRESS<br>Environmental Sciences Research Laboratory - RTP, NC<br>Office of Research and Development<br>U.S. Environmental Protection Agency<br>Research Triangle Park, NC 27711 | | 13. TYPE OF REPORT AND PERIOD COVERED<br>Final<br>14. SPONSORING AGENCY CODE<br>EPA/600/09 |

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| *Air pollution<br>*Emission<br>*Environmental surveys<br>*Sources | St. Louis, MO | 13B<br>05J |

| | | |
|---|---|---|
| 18. DISTRIBUTION STATEMENT<br>RELEASE TO PUBLIC | 19. SECURITY CLASS *(This Report)*<br>UNCLASSIFIED | 21. NO. OF PAGES<br>160 |
| | 20. SECURITY CLASS *(This page)*<br>UNCLASSIFIED | 22. PRICE<br>A08-A01 |

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

# REGIONAL AIR POLLUTION STUDY

## Point Source Methodology and Emission Inventory

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Contract 68-02-2093
Task Order 108A

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# ABSTRACT

The development of the point source emission data inventory for the Regional Air Pollution Study at St. Louis is discussed. To meet the unusual requirements of this study, which specified the acquisition of hourly measured emission data for the St. Louis Air Quality Control Region for a period of two years, a unique methodology was developed and put into practice. The result is a data base containing over 20 million pieces of information in a readily accessible form.

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# ACKNOWLEDGMENTS

Many people contributed to the success of this study. The cooperation of the almost one hundred companies in the St. Louis area is greatfully acknowledged. Officials of the Illinois Environmental Protection Agency, the Missouri Air Conservation Commission, the St. Louis County and St. Louis City Air Pollution Control Agencies, and, last but not least, the EPA Project Officers, Mr. Chuck Masser and Mr. Jim Southerland, were most helpful and cooperative.

At the St. Louis Regional Office, staff members R. W. Griscom, O. C. Klein, John Piere and Kevin Isam were among the chief contributors to the technical effort. But the work could not have been successfully accomplished without the faithful labors of the data clerks, Mss. S. Piere, S. Wosmansky, B. V. Kruse and A. J. Haspert.

# A. RAPS POINT SOURCE METHODOLOGY

## 1.0 INTRODUCTION

An emission inventory constitutes the starting point for any attempt to control emissions to the atmosphere. As long as such controls deal with average yearly concentrations, inventories giving total annual emissions of the various sources of pollutants are sufficient. The Regional Air Pollution Study had, however, as its first goal the validation of atmospheric dispersion models, which attempt to predict ambient pollutant concentrations on an hourly basis. Emission values derived from total annual emissions were therefore largely inadequate, and the RAPS emission inventory was conceived to provide the needed resolution and accuracy by measuring and recording hourly emissions (or parameters directly related to hourly emissions) for the principal sources of pollution. Thus, the emission inventory for the Regional Air Pollution Study (RAPS) at St. Louis is distinguished from existing emission inventories by two factors: its resolution and its accuracy.

Although ultimately all pollutants of importance were included in this inventory, as a matter of priority emphasis of the data collection was placed on $SO_2$ as an indicator of pollution originating from stationary sources. Hourly measurement provided the needed time resolution and, at the same time, increased the accuracy of the emission inventory by updating it. Later, the inventory was expanded to include hydrocarbons, oxides of nitrogen, particulate matter, heat emissions and others.

Any attempt to obtain measured values for a large number of sources is a complex and expensive undertaking. Within the usual constraints of air pollution studies, such an approach is not feasible, and the use of algorithms or models has been generally resorted to for estimation of emissions. Since such emission models describe assumed conditions, their use in the RAPS was less desirable; they were used only where it did not impair the overall accuracy of the inventory, as indicated by a sensitivity analysis.

This section of the report discusses the approach to the problem of

assembling a "precision" inventory for the St. Louis Interstate Air Quality Region. It states the nature of the problem and the rationale for choosing the St. Louis area as a "test chamber"; the pollutants of interest are also discussed briefly. Using an approach suggested by EPA's Weighted Sensitivity Analysis Program, limits were placed on the scope of the investigation, which were then applied to the actual situation in St. Louis. The mechanism for the acquisition of data and their preparation prior to entry into a data bank are also described.

## 2.0 THE SAINT LOUIS INTERSTATE AIR QUALITY CONTROL REGION (AQCR #070)

The St. Louis area was selected on the basis of careful considerations of the various factors of importance for a regional air pollution study (1). Standard Metropolitan Statistical Areas (SMSA's) were used as a basis for the analysis, and all SMSA's with population in excess of 400,000 were examined. The primary factors considered in the selection were:

- Geographic isolation from other SMSA's
- Location within the Continental climate zone
- Significant level and density of pollutant emissions
- Presence of a rural fringe with substantial crop lands
- Existence of control programs and historical data

The final selection of St. Louis was made by the Assistant Administrator for Research and Monitoring, EPA, from the four considered sites on the basis of the following rating (Table 1):

TABLE 1. QUALIFICATIONS OF SELECTED SMSA'S

| Criterion | Birmingham | Cincinnati | Pittsburgh | St. Louis |
|---|---|---|---|---|
| Surrounding area | Fair | Poor | Good | Good |
| Heterogeneous emissions | Fair | Fair | Fair | Good |
| Area size | Good | Good | Good | Good |
| Control program | Poor | Good | Good | Good |
| Information | Poor | Good | Fair | Good |
| Climate | Good | Fair | Fair | Good |

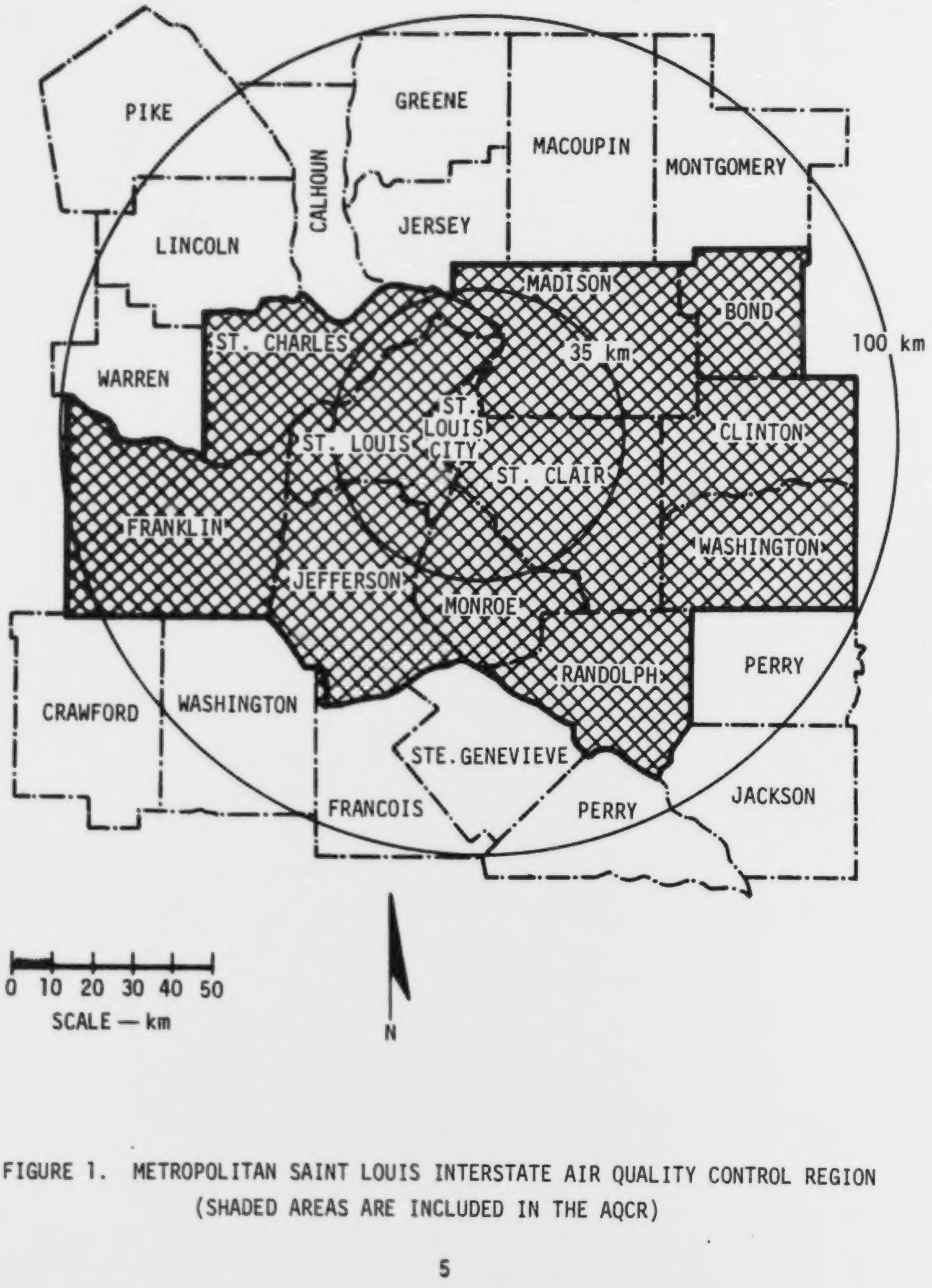

PIKE
GREENE
MACOUPIN
MONTGOMERY
CALHOUN
JERSEY
LINCOLN
MADISON
BOND
ST. CHARLES
35 km
100 km
WARREN
ST. LOUIS CITY
ST. LOUIS
CLINTON
ST. CLAIR
FRANKLIN
WASHINGTON
JEFFERSON
MONROE
RANDOLPH
PERRY
CRAWFORD
WASHINGTON
STE. GENEVIEVE
FRANCOIS
PERRY
JACKSON
0 10 20 30 40 50
SCALE — km
N

FIGURE 1. METROPOLITAN SAINT LOUIS INTERSTATE AIR QUALITY CONTROL REGION (SHADED AREAS ARE INCLUDED IN THE AQCR)

## 3.0 HISTORICAL INVENTORY DATA

Air pollution studies have been conducted in the St. Louis area for many years, and several emission inventories have been developed. In 1964, an "Interstate Air Pollution Study, Saint Louis-East Saint Louis Metropolitan Areas" was undertaken by the U.S. Public Health Service. Questionnaires were sent out to determine fuel use and combustible waste disposal practices in the area as well as manufacturing activities. A revised emission inventory, still based on 1963 data, was published in December 1966 as Phase II of the Interstate Study.

After the Metropolitan Saint Louis Interstate Air Quality Control Region had been established, the first comprehensive inventory was taken in 1968, to serve as a basis for the Implementation Planning Program (IPP). Since then, four more inventories have been compiled:

- IBM Emission Inventory-1970
- DAQED Emission Inventory-1971
- NATO Emission Inventory-1971
- NEDS Emission Inventory-1973

In addition, the following traffic and transportation inventories exist:

- Streets and highways
- Railways and vessels

The emission inventories in current use by the Missouri and Illinois regulatory agencies were recently (Summer 1973) acquired and transferred to the NEDS files.

These inventories are described in detail in SRI Report "A Regional Air Pollution Study Preliminary Emission Inventory" (2).

Most of these inventories are only of historical interest. Current data are contained in the National Emission Data System (NEDS) (3) inventory, administered by the Federal EPA, which is based on inventories kept by the

Illinois EPA and the Missouri agencies.

The NEDS inventory contains information on annual emissions of the five "criteria" pollutants (particulates, $SO_2$, $NO_X$, hydrocarbons (HC) and CO) from stationary point and area sources, as well as a listing of selected industrial materials emitted by chemical process, food, agriculture, chemical and mineral products industries, petrochemical operations, wood processing, and incinerators.

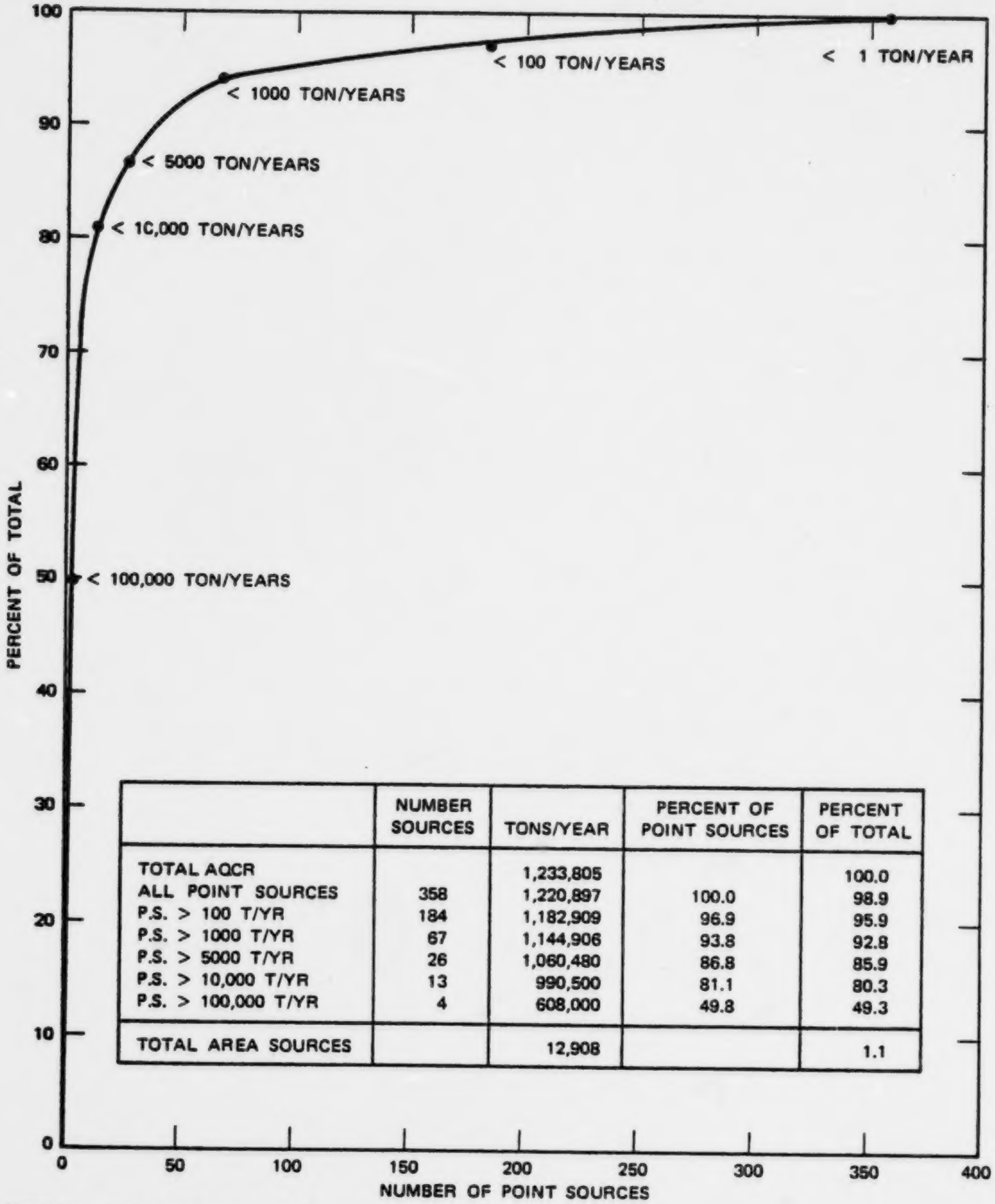
From the point of view of the Regional Air Pollution Study, the NEDS inventory had two major uses: it contained emission data for those sources for which detailed data were unavailable, and it provided a basis for an analysis of the problem of obtaining measured data. It therefore served as an interim data base for the St. Louis study until the RAPS inventory became operational.

## 4.0 SIZE DISTRIBUTION OF SOURCES

The situation in St. Louis lent itself to a direct attack on the problem of direct measurement of emissions because of the relatively limited number of major point sources. In terms of $SO_2$, the current (1973) National Emission Data System (NEDS) inventory listed about 300 sources emitting over ten tons of $SO_2$ per year. Of these, only 62 emit in excess of 1000 tons/year, an additional 120 over 100 tons/year. The 62 largest sources, representing 15 companies, are concentrated at 20 locations. Thus, the sheer physical magnitude of the problem of collecting hourly data for the major sources of pollution appeared to be manageable within a reasonable budget (Figure 2).

The situation for other pollutants is somewhat similar. The data are summarized in Table 2.

Thus, if direct measurements of emission were to be limited to sources emitting in excess of 1000 tons/year, we needed to obtain data from 62 sources at 20 locations for $SO_2$, 13 sources at 9 locations for CO, 28 sources at 12 locations for particulates, and so on. Many of these sources overlap, thus further reducing the data collection (but not the data recording) problems. For example, of the 26 major sources of $NO_X$, 21 are also major emitters of $SO_2$. The extent of the overlap is shown in Table 3, which lists all major sources of pollutants in matrix form.



| | NUMBER SOURCES | TONS/YEAR | PERCENT OF POINT SOURCES | PERCENT OF TOTAL |
|---|---|---|---|---|
| TOTAL AQCR | | 1,233,805 | | 100.0 |
| ALL POINT SOURCES | 358 | 1,220,897 | 100.0 | 98.9 |
| P.S. > 100 T/YR | 184 | 1,182,909 | 96.9 | 95.9 |
| P.S. > 1000 T/YR | 67 | 1,144,906 | 93.8 | 92.8 |
| P.S. > 5000 T/YR | 26 | 1,060,480 | 86.8 | 85.9 |
| P.S. > 10,000 T/YR | 13 | 990,500 | 81.1 | 80.3 |
| P.S. > 100,000 T/YR | 4 | 608,000 | 49.8 | 49.3 |
| TOTAL AREA SOURCES | | 12,908 | | 1.1 |

**SOURCE:** NEDS Inventory (1973).

SA-2579-14

FIGURE 2. $SO_2$ EMISSIONS FOR THE SAINT LOUIS AIR QUALITY CONTROL REGION

## TABLE 2. SOURCES OF POLLUTANTS IN THE ST. LOUIS AQCR

| POLLUTANT | $SO_2$ | | | | CO | | | | PARTICULATE | | | | $NO_x$ | | | | HYDROCARBONS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tons/Year | $>10^3$ | $>10^2$ | $>10$ | Total | $>10^3$ | $>10^2$ | $>10$ | Total | $>10^3$ | $>10^2$ | $>10$ | Total | $>10^3$ | $>10^2$ | $>10$ | Total | $>10^3$ | $>10^2$ | $>10$ | Total |
| No. of Sources | 62 | 121 | 121 | 304 | 13 | 18 | 62 | 92 | 28 | 78 | 165 | 271 | 26 | 83 | 256 | 365 | 23 | 80 | 165 | 279 |
| No. of Locations | 20 | 15 | 17 | 52 | 9 | 8 | 13 | 30 | 12 | 25 | 29 | 66 | 10 | 13 | 36 | 59 | 10 | 22 | 24 | 56 |
| No. of Companies | 15 | 11 | 17 | 43 | 7 | 4 | 13 | 24 | 9 | 25 | 29 | 63 | 6 | 10 | 34 | 50 | 10 | 19 | 22 | 51 |

Source: National Emission Data System, Condensed Point Source Listings, AQCR (070), December 1973.

## TABLE 3. SOURCES OF POLLUTANTS IN THE ST. LOUIS AQCR EMITTING IN EXCESS OF 1000 TONS/YEAR

| Source Name | Point No. | Pollutant | | | | | Proposed Stack Sampling |
|---|---|---|---|---|---|---|---|
| | | $SO_2$ | CO | Partic- ulates | $NO_X$ | HC's | |
| Allied Chemicals | 01 | x | | | | | |
| Alpha Cement Co. | 01 | | | x | | | |
| Alton Box Co. | 01 | x | | | x | | |
| | 02 | x | | | | | |
| | 03 | x | | | | | |
| Amoco | 01 | x | x | x | | x | x |
| | 02 | x | | | | | |
| | 03 | x | | | | | x |
| | 04 | x | | | x | | x |
| | 05 | | | | | x | |
| | 06 | | | | | x | |
| Anheuser-Busch Co. | 01 | x | | | | | |
| Anlin Corp. | 01 | x | | | | | x |
| Chrysler Corp. | 01 | | | | | x | |
| | 02 | | | | | x | |
| Clark Oil Co. | 01 | x | x | x | | x | |
| | 02 | | | | | x | |
| | 03 | | | | | x | |
| | 04 | | | | | x | |
| Columbia Quarry | 01 | | | x | | | |
| | 02 | | | x | | | |
| East St. Louis Stone | 01 | | | x | | | |
| Ford Motor Co. | 01 | | | | | x | |
| | 02 | | | | | x | |

(continued)

TABLE 3 (continued)

| Source Name | Point No. | Pollutant |  |  |  |  | Proposed Stack Sampling |
|---|---|---|---|---|---|---|---|
|  |  | $SO_2$ | CO | Particulates | $NO_X$ | HC's |  |
| GMAC | 01 |  |  |  |  | x |  |
|  | 02 |  |  |  |  | x |  |
|  | 03 |  |  |  |  | x |  |
|  | 04 |  |  |  |  | x |  |
| Granite City Steel | 01 |  | x | x |  |  |  |
|  | 02 |  | x | x |  |  |  |
|  | 03 |  | x | x |  |  |  |
|  | 04 |  | x | x |  |  |  |
|  | 05 |  | x | x |  |  |  |
| Highland Electric Co. | 01 | x |  |  |  | x |  |
| Illinois Power Co. | 01 | x | x |  | x |  |  |
|  | 02 | x | x | x | x |  | x |
|  | 03 | x |  |  | x |  |  |
|  | 04 | x |  |  | x |  |  |
|  | 05 |  |  |  | x |  |  |
|  | 06 |  |  |  | x |  |  |
|  | 07 |  |  |  | x |  |  |
|  | 08 | x |  |  | x |  |  |
|  | 09 | x |  | x | x |  | x |
|  | 10 | x |  | x | x |  |  |
|  | 11 | x |  | x | x |  |  |
| Laclede Steel | 01 | x |  |  | x |  |  |
|  | 02 |  | x |  |  |  |  |
|  | 03 |  | x |  |  |  |  |
| Mississippi Lime Co. | 01 |  |  | x |  |  |  |
| Mississippi Portland Cement |  |  |  |  | x |  |  |
| Monsanto Chemical Co. | 01 | x |  |  |  |  |  |
|  | 02 | x |  | x |  |  | x |

(continued)

### TABLE 3 (continued)

| Source Name | Point No. | Pollutant | | | | | Proposed Stack Sampling |
|---|---|---|---|---|---|---|---|
| | | $SO_2$ | CO | Particulates | $NO_X$ | HC's | |
| Monsanto Chemical Co. | 02 | x | | x | | | x |
| | 03 | x | | | | | |
| | 04 | x | | x | | | x |
| | 05 | x | | x | | | |
| | 06 | x | | x | | | x |
| | 07 | x | | x | | | |
| | 08 | | x | | | | |
| | 09 | | x | | | x | |
| Municipal Incinerator | 01 | | x | | | | |
| | 02 | | x | | | | |
| NL Titanium Div. | 01 | x | | | | | |
| | 02 | x | | | | | x |
| | 03 | x | | | | | |
| | 04 | x | | | | | |
| P P G Glass | 01 | x | | | | | |
| St. Joseph Lead Co. | 01 | x | | | | | x |
| | 02 | x | | | | | x |
| Shell Oil Co. | 01 | x | | | | | |
| | 02 | x | | | | | |
| | 03 | x | | | | | x |
| | 04 | x | | | | | |
| | 05 | x | | x | | x | x |
| | 06 | x | | x | | x | |
| | 07 | x | | | | | |
| | 08 | x | | | | | x |
| | 09 | x | | | | | |
| | 10 | x | | | | | |
| | 11 | | | | | x | |
| | 12 | | | | | x | |

(continued)

TABLE 3 (continued)

| Source Name | Point No. | Pollutant | | | | | Proposed Stack Sampling |
|---|---|---|---|---|---|---|---|
| | | $SO_2$ | CO | Partic-ulates | $NO_X$ | HC's | |
| Socony | 01 | | | | | x | |
| Stolle Quarry | 01 | | | x | | | |
| | 02 | | | x | | | |
| Texaco | 01 | | | | | x | |
| Union Electric | 01 | x | | | x | | |
| | 02 | x | | | x | | |
| | 03 | x | | x | x | | |
| | 04 | x | | x | x | | |
| | 05 | x | | | x | | |
| | 06 | x | | | x | | |
| | 07 | x | | | x | | |
| | 08 | x | | | x | | |
| | 09 | x | | x | x | | x |
| | 10 | x | | x | x | | x |
| | 11 | x | | | x | | |
| | 12 | x | | | | | |
| | 13 | x | | | | | |
| | 14 | x | | | | | |
| | 15 | x | | | | | |
| | 16 | x | | | | | |
| | 17 | x | | | | | |
| TOTALS | 96 | 62 | 13 | 28 | 26 | 23 | 17 |

## 5.0 SENSITIVITY ANALYSIS

An important aspect of every inventory is its accuracy. While no inventory can be better than the numbers supplied by the data acquisition process, a statistical estimate of the overall quality and probable error helps to place the uncertainties on a quantitative basis.

As a first approach to this problem, the National Air Data Branch of EPA commissioned a study which produced a Weighted Sensitivity Analysis Program (4). While this program does not supply any estimates of the absolute accuracy, it does help evaluate the maximum permissible error of any part of the inventory, given a maximum permissible error for the whole system. In doing so, it keeps the inventory at an equivalent level of accuracy and points out areas where accuracy has to be improved to provide a desired overall accuracy. In addition, it also provides an approach to establish confidence levels for the emission inventory.

The basic theoretical development proceeds as follows. The linear model:

$$Q^2\Theta^2 = \sum_{k=1}^{N} Q_k^2 \ \sigma_k^2$$

where $Q$ = total amount of pollutant emitted
$100\ \Theta$ = percentage error associated with $Q$
$Q_k$ = amount of pollutant emitted by subclass k
$100\ \sigma_k$ = percentage error associated with $Q_k$

is postulated as an appropriate model to analyze the propagation of errors through the emission inventory.

If each subclass contributes to the error an amount proportional to its relative physical contribution, it can be shown that

$$\sigma_k = \Theta \frac{Q}{Q_k}$$

The analysis demonstrates that to obtain a predetermined level of precision for a source class, not all subclasses need to be measured with the same precision; the greater the ration of $Q:Q_k$ becomes, the greater becomes the allowable value of $\sigma_k$. Conversely, $\sigma_k$ approaches the value of $\Theta$ as the ratio approaches unity (Figure 3).

The authors also developed a method for predicting the confidence level for the inventory; that is, the probability that the actual overall error will not exceed $\Theta$, using Chebyshev's theorem (5). The results for selected pairs of ($\alpha$ and 1-c) are shown in Table 4, where $\alpha = 2\theta$ and 1-c is the confidence level.

Thus, a two-step procedure was suggested. First, the overall allowable error $\theta$ was established, either from user's (modeler's) requirements, or as a tradeoff between confidence level and acceptable error interval; secondly, the values of $\sigma_k$ for the components of interest were computed.

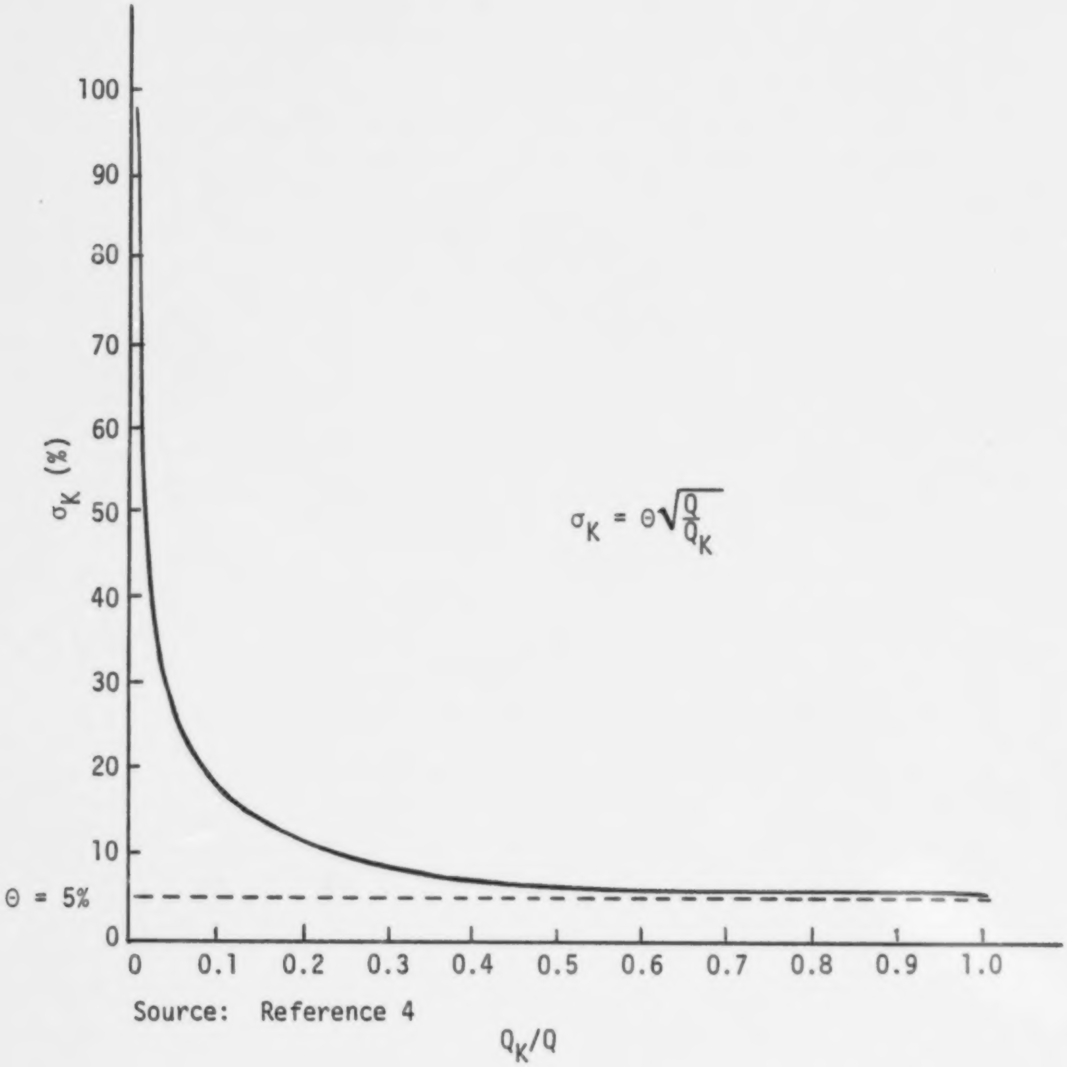
Applying these considerations to our case suggested that, in the absence of any definite information about the modeler's requirements for the accuracy of emission data, a fairly stringent set of conditions would be a confidence level of 95 percent and an acceptance interval of 10 percent (these conditions are probably stricter than the accuracy of the emission data). This would lead to a permissible maximum error $\theta$ of 2.24%.

The allowable error for source classes of various sizes, such as 100 tons/year, 1000 tons/year, etc. could then be calculated. For example, the allowable error for a 100 ton source of $SO_2$ was

$$\begin{aligned} \sigma 100T &= \Theta \frac{Q}{Q_{100T}} \\ &= 2.24 \frac{1,187.296}{100} \\ &= 244\% \end{aligned}$$

The data are tabulated in Table 5.

The very large $\sigma_k$ for $SO_2$, CO and $NO_X$, even for the relatively stringent statistical conditions, suggested that there probably was no need to obtain



Source: Reference 4

FIGURE 3. RELATIONSHIP BETWEEN $\sigma_K$ AND $Q_K/Q$

TABLE 4. VALUES OF $\theta$ FOR SELECTED PAIRS ($\alpha$, 1-C)

Confidence Level

| Acceptance Interval | 1-C<br>$\alpha$ | 90% | 95% | 99% |
|---|---|---|---|---|
| | 5% | 1.58% | 1.12% | 0.5% |
| | 10% | 3.16% | 2.24% | 1.0% |
| | 20% | 6.32% | 4.47% | 2.0% |

Source: Reference 4

TABLE 5. MAXIMUM ALLOWABLE ERROR FOR POINT SOURCES OF VARIOUS SIZES

Acceptance Interval 10%, Confidence Level 95%, $\Theta$ = 2.24%

| Pollutant | Total Emissions Tons/Year | Allowable Error $\sigma_k$ for Sources of | | |
|---|---|---|---|---|
| | | 100 Tons/Yr | 1000 Tons/Yr | 10,000 Tons/Yr |
| Particulates | 45,224 | 48% | 15% | -- |
| $SO_2$ | 1,007,530 | 225% | 71% | 23% |
| $NO_X$ | 322,730 | 127% | 40% | -- |
| HC | 47,610 | 49% | 15% | -- |
| CO | 164,331 | 91% | 29% | -- |

measured hourly values for sources smaller than 100 tons/year of these pollutants, since annual data provided this accuracy. Thus, the collection of hourly data was limited to sources of 1000 ton/year and larger. As indicated in Table 2, this reduced the number of $SO_2$ sources to be measured to 62, the stationary CO sources to 13, and the $NO_X$ sources to 26. Hourly values for the remaining sources were then calculated as discussed in Section 7.2.2.

## 6.0 SOURCES OF AIR POLLUTION

### 6.1 CLASSIFICATION

Virtually every human activity results in some form and degree of air pollution. For practical purposes, it is convenient to classify the sources of emission; a general classification is shown in Table 6. There, sources are divided into stationary and mobile, since these present significantly different problems. Stationary sources are further divided into Point and Area sources. The division between the two is arbitrary: individually identified sources are considered "Point Sources". For the RAPS inventory, sources emitting less than 0.01% of the total emissions of a pollutant were not considered as individual points but rather assigned to and distributed over the appropriate area. Resultant point source values were approximately 100 tons/year for $SO_x$, 30 tons/year for $NO_x$, 25 tons/year for particulates, 10 tons/year for hydrocarbons, and 10 tons/year for carbon monoxide. Of course, even a very small point source can be a major contributor to a given local or nearby receptor (monitoring station), but the investigation of this problem constitutes a localized, special situation which needs to be dealt with separately from the overall inventory.

The division of sources into combustion and non-combustion is again a matter of convenience; however, combustion sources constitute a specific group of emitters which in some cases, such as $SO_2$ for stationary sources, constitute the overwhelming fraction of these pollutants.

### 6.2 POLLUTANTS OF INTEREST

The RAPS inventory initially emphasized "criteria" pollutants (for which Air Quality Standards exist). Ultimately the inventory also included other pollutants such as trace and hazardous contaminants.

#### 6.2.1 Sulfur Dioxide

Sulfur dioxide ($SO_2$) was the pollutant initially emphasized in the

## TABLE 6. CLASSIFICATION OF SOURCES FOR EMISSION INVENTORY

| Source Category | Stationary Sources | | | | Mobile Sources | |
|---|---|---|---|---|---|---|
| Source Subcategory | Area Sources | | Point Sources | | Area and Line Sources | |
| Source Process | Combustion | Noncombustion | Combustion | Noncombustion | Combustion | Noncombustion |
| Source units | Commercial<br>Institutional<br>Residential<br>Small industrial<br>Fuel Use<br>Space heaters<br>Water heaters<br>Boilers<br>Waste disposal--incinerators | Commercial<br>Small industrial--Venting of organic vapors (dry cleaning, painting, gasoline storage and handling, food preparation) | Utilities<br>Power plants<br>Municipal--incinerators<br>Industrial<br>Boiler and power plants<br>Indirect-fired air and process heaters<br>Stationary internal combustion engines<br>Stationary gas turbine engines<br>Incinerators | Industrial<br>Direct-fired process units<br>All other industrial processes, material storage and handling | Surface vehicles<br>Passenger cars<br>Trucks and buses<br>Commercial vehicles<br>Railroads<br>Vessels<br>Off-highway vehicles and equipment<br>Aircraft<br>Piston engines<br>Gas turbines | Surface vehicles and aircraft<br>Venting of fuel vapors<br>Wear of tires and brakes |
| Pollutants | Gases and vapors<br>$SO_x$<br>$NO_x$<br>CO<br>Hydrocarbons and derivatives<br>HCl<br>HF<br>Odors<br>Particulates<br>Fly ash and its specific chemical components<br>Smoke | Gases and vapors<br>Organic vapors (solvents, gasoline)<br>Odors<br>Particulates<br>Organic aerosols<br>Smoke | Gases and vapors<br>$SO_x$<br>$NO_x$<br>CO<br>Hydrocarbons and derivatives<br>HCl<br>HF<br>Odors<br>Particulates<br>Fly ash and its specific chemical components<br>Smoke | All pollutants | Gases and vapors<br>$SO_x$<br>$NO_x$<br>CO<br>Hydrocarbons and derivatives<br>Odors<br>Particulates<br>Smoke<br>Lead<br>Oil aerosols<br>Derivatives of fuel additives | Hydrocarbon vapors<br>Particulates<br>Organic<br>Inorganic |

inventory since it occupied the position of highest priority within the Regional Air Pollution Study. In St. Louis, virtually all of it (98.9%) was estimated to originate from listed point sources. Most of the $SO_2$ is produced by the combustion of coal and fuel oil, although some of it resulted from ore roasting, steel production, and petroleum refining operations. The largest contributors are the power generating stations of the utility companies. The six generating stations in the St. Louis area produce over 855,000 tons of $SO_2$ per year, or about 85% of all the $SO_2$ produced by point sources in the area.

Sulfur dioxide is relatively non-reactive in the atmosphere, at least over the time interval of a few hours, which is likely to be of interest to modelers. Removal from the atmosphere occurs by several mechanisms, some of which involve oxidation to sulfur trioxide with subsequent formation of sulfuric acid mist or sulfates by reaction with basic materials in the atmosphere (e.g., ammonia). These processes will have to be considered for long-term (24 hours or longer) modeling.

Available evidence indicates that the ratio of $SO_2$ to $SO_3$ in ambient air is between 50:1 to 100:1. Recent health data (6) indicate that (at least in the case of elderly patients with heart and lung diseases, as well as asthmatics) it is the level of suspended sulfates that correlates with adverse health effects rather than the $SO_2$ level. Best estimates indicate that sulfates are about an order of magnitude more irritating than $SO_2$. At this time, it is not clear whether sulfuric acid mist or sulfates are implicated, and the importance of atmospheric transformation products of $SO_2$ is not certain.

Ambient concentrations of $SO_2$ in the St. Louis atmosphere typically range from 20 to 40 micrograms/$m^3$ (annual average) (6).

### 6.2.2 Carbon Monoxide

Carbon monoxide (CO) is closely linked with automotive traffic. Stationary combustion sources normally generate only minor amounts of CO. There are, however, a few important industrial sources of CO: the catalytic cracker regenerators in petroleum refineries, blast furnaces in steel mills, and certain chemical processes. Because of the tremendous volume of stack gases generated by electric utilities, the relatively low concentrations of CO in these gases also contribute to the overall CO concentration.

Carbon monoxide is chemically inert. It is removed slowly by contact with certain soil bacteria, which maintain the natural balance of CO in the air, but the rates of these processes are not significant on the time scale of interest.

Carbon monoxide combines with hemoglobin 200 times more readily than oxygen; it thus prevents the blood hemoglobin from transporting oxygen from the lungs to the tissues. Exposure to low concentrations (below 100 ppm or 115 mg/m$^3$) causes headaches and dizziness. Its actions are most likely to affect persons living at high altitudes and people with chronic heart and lung diseases. Cigarette smokers commonly have 5 - 10% carboxy-hemoglobin, an amount that corresponds to 30 to 60 ppm of CO in ambient air (35 to 70 mg/m$^3$).

Ambient concentrations of CO in the downtown St. Louis area range from 15 to 35 milligrams/m$^3$ (6).

### 6.2.3 Particulate Matter

The fate of particulate matter in the atmosphere is becoming a major research target. It is a particularly difficult subject because the characteristics of particles are determined only partially by their chemical comsition and very largely by their size. Thus haziness, by far the most obvious manifestation of air pollution, is strongly dependent on particle size. Similarly, the health effect of particulate matter is largely dependent on particle size, since only particles of a certain size range penetrate into the lungs and are retained there. The particle size of interest in these areas is of the order of less than five or six micrometers. Such particles remain afloat virtually indefinitely and, while their contribution to the total weight of particulate matter is small, their number is very large.

By contrast, the emission of particulate matter is determined on a weight basis, whether by sampling or by material balance consideration. Thus the small number of relatively large particles accounts for most of the mass of particulate emission. Since particles in excess of 10 μm settle out rather rapidly, these particles do not contribute much to the ambient concentration of particulates, nor to their health and visibility effects.

Thus, a really useful inventory of particulate emissions should specify not only the mass but also the size distribution of particulate emission in addition to their chemical composition--a difficult and expensive task which cannot be carried out on a routine monitoring basis.

The problem is further complicated by the processes which form particulates--mainly droplets--in the atmosphere. The formation of $SO_3$ leads directly (via reaction with water vapor) to the formation of a sulfuric acid mist and to the stabilization of fog; photochemical reactions result in the polymerization of initially gaseous hydrocarbons, resulting again in particulate droplets. These products are only indirectly related to emission inventories. The concentration of suspended particulates in the St. Louis area ranges from 50 to 150 $\mu m/m^3$.

### 6.2.4 Hydrocarbons

In the air pollution literature, the term "hydrocarbons" is used loosely to designate gaseous organic compounds. There are two major categories of sources of hydrocarbons in urban atmospheres: incomplete combustion and evaporation. Incomplete combustion occurs primarily in internal combustion engines (automobiles). Evaporation results from the storage and handling of solvents, petroleum products, etc. Additionally, methane is a normal constituent of the atmosphere, the result of natural decomposition processes.

Hydrocarbons participate in photochemical reactions leading to "smog", but their reactivity varies widely. It is therefore important to determine not only the amount of hydrocarbons present, but also their composition. Separation into unreactive hydrocarbons, olefins, paraffins, aromatics and aldehydes has been carried out in the Los Angeles area and will be performed in St. Louis. Complete analyses of samples collected in bags by means of a gas chromatography are scheduled for samples of ambient air in St. Louis.

### 6.2.5 Oxides of Nitrogen ($NO_X$)

Emission inventories of nitrogen oxides constitute a special problem since these compounds--particularly nitric oxide (NO)--are primarily formed by nitrogen fixation during combustion operations. Their formation during combustion is a complex function of the time-temperature relationships and the combustion configuration. Any nitrogen compounds present in the fuel also contribute to the formation of nitrogen oxides. Because of this, the nitrogen oxide concentration in flue gases cannot be calculated from a theoretical basis but must be determined experimentally for, at least, each typical situation. In addition to combustion sources, there are several specific point sources in the area which emit nitrogen oxides, usually $NO_2$, such as nitric acid plants.

As mentioned previously, the importance of oxides of nitrogen and hydrocarbons as pollutants is primarily as participants in photochemical reactions where $NO_2$ acts as primary light absorber. These compounds will therefore be of importance to RAPS when a study of photochemical reactions in the atmosphere is carried out.

Ambient concentrations of $NO_x$ in AQCR 70 tend to be between 35 μg and 75 μg per cubic meter of air.

### 6.2.6 Heat Emissions

The large amounts of energy produced and consumed by a city eventually are converted into heat, resulting in a "heat island" which has an effect on atmospheric stability and thus affects modeling efforts. A heat emission inventory is required for a comprehensive understanding of this effect in much the same way as a pollutant emission inventory forms the basis for an understanding of the fate of the pollutants.

Point sources contribute significantly to the heat emission inventory, since a sizeable portion of the energy consumed is wasted as stack gases. Even in highly efficient power plants, about 15 percent of the energy consumed is wasted at the plant. In some industrial operations, such as flares, all of the heat of combustion is released to the atmosphere at the plant.

In a self-contained area such as St. Louis, not only the waste heat turns up as heat emissions, but virtually all of the converted energy as well. Except for minor amounts of energy stored as chemical energy (e.g., in a primary aluminum plant) or radiated into space as visible light, all other forms of energy, whether electrical or mechanical, are converted into heat and released into the atmosphere, spread out over the inhabited area. Thus, as a first approximation, the total Btu content of the fuel used at St. Louis can be assumed to be released at either point or area sources. The amount of heat released by point sources can be calculated directly from fuel consumption and known conversion efficiencies of the power boilers; it can be verified by stack analysis and measurement of gas volume and temperature, from which the heat content can be calculated.

Since fuel consumption figures are obtained for other purposes, a program to calculate heat emission from point sources can be initiated. Significant point sources, defined similar to pollution point sources, should be treated individually. All other sources are assigned to grid squares, whose total emission is then estimated. Power generation is treated separately, since a large fraction of the waste heat is carried off in cooling water.

## 7.0 EMISSION DATA ACQUISITION

A series of sequential steps leads to the eventual acquisition and recording of point source inventory data for the RAPS inventory. The steps are:

- Survey
- Classification of Sources into Acquisition Groups
- Acquisition of Data by:
  1) Fuel consumption or process data
  2) Derivation from operational data
  3) Stack analyses
- Transformation of Data and Entry into Computer Bank

## 7.1 SURVEY

Classically, data for emission inventories are acquired by the use of questionnaires which are either mailed out or prepared by the interviewer or inspector on a one-time basis.

The requirements of the RAPS inventory for hourly measured data for a period of a year far exceed the normal reporting routine and require special arrangements with the management of the various facilities. Thus, personal contact with the appropriate corporate office by mail, phone and, ultimately, in person is essential to obtain the necessary cooperation. The requests are made for access to data which would provide a basis for calculating hourly emissions.

Such data could be

- stack concentration measurements
- fuel consumption records
- process data
- steam production records
- power production records

These data, coupled with the necessary secondary information, such as stack gas volume, concentration of sulfur in fuel or in process materials, etc., permitted the calculation of the weight estimates of pollutant (e.g., $SO_2$) emitted per hour.

There are two levels at which the initial information has to be gathered:

- Management level
- Operational level

At the management level, an "agreement in principle" is required; usually operational personnel is present at these meetings since they will later on be involved. After an agreement is reached, the details of the data acquisition are worked out with operational personnel.

For point sources emitting less than 1000 tons/year, as well as those major sources where detailed data are not available, hourly emissions have to be derived by a model, as discussed further on under 7.3.2. For these sources, the following information is necessary.

1. Source description
2. Work schedule
3. Maximum process and space heating loads
4. Monthly and shift fuel weighting
5. Fuel analysis data

## 7.2 ACQUISITION OF DATA

The division of sources of pollutants into major (those emitting more than 1000 tons per year) and minor (emitting between 100 and 1000 tons/year), which is based on sensitivity analysis discussed above, produced two broad categories. Data from sources in Category 1, the major sources, were to be collected on an hourly basis to the extent that they were available. Data from all other sources, that is the minor ones and those of the larger ones where detailed data are not available, were to be derived by a modeling or algorithmic procedures.

In Group 1 are the utilities and the majority of sources emitting over 1000 tons/year of pollutant, as determined by the initial survey of sources.

The data available from these sources permit a direct calculation of the weight of pollutants emitted any given hour.

Although sources in Group II contribute only a minor portion of the overall pollutant load, they may be of considerable significance locally. Under certain conditions it may become necessary to obtain measured emission data from some of these sources as a special project.

### 7.2.1 Fuel Consumption and Process Data

From the point of view of sampling methodology, there is no procedural difference between emission data based on fuel consumption and data based on processing of, for example, a sulfide ore. In both cases, the hourly weight of consumed material determines the amount of gaseous discharge.

From an analysis of existing inventories and discussions with local air pollution agencies, it appeared that the 62 point sources emitting in excess of 1000 tons of $SO_2$ per year fell into the following categories (Table 7).

TABLE 7. CLASSIFICATION OF $SO_2$ SOURCES

| SCC Code | Category | Number |
|---|---|---|
| 1-01 | Boilers, Electric Generation | 27 |
| 1-02 | Boilers, Industrial | 19 |
| 3-05 | Petroleum Processing | 11 |
| 3-xx | Other Industrial | 5 |

Thus, almost 75% (46) of the 62 sources (including all of the large ones) are boilers; another 17% are concentrated in the petroleum industry.

Carbon monoxide, another combustion-related pollutant, has quite a different distribution (Table 8).

TABLE 8. CLASSIFICATION OF CO SOURCES

| SCC Code | Category | Number |
|---|---|---|
| 1-01 | Boilers, Electric Generation | 1 |
| 3-01 | Chemical Process | 2 |
| 3-03, 3-04 | Metal Processing | 6 |
| 3-06 | Petroleum Processing | 2 |
| 5-01 | Incinerators | 2 |

Here the largest sources are metal processing (blast furnaces, etc.), petroleum processing (cat. cracking) and certain chemical processes.

Particulate emissions are largely related to boilers; almost half of the emission sources are boilers; another 25% comes from the mineral industry (quarries, cement plants, etc.). The breakdown is shown in Table 9. The overlap of pollutants from different sources has been indicated in Table 3.

TABLE 9. CLASSIFICATION OF SOURCES OF PARTICULATES

| SCC Code | Category | Number |
|---|---|---|
| 1-01 | Boilers, Power | 13 |
| 3-03 | Metal Industry | 4 |
| 3-05 | Mineral Industries | 7 |
| 3-06 | Petroleum Processing | 4 |

TABLE 10. CLASSIFICATION OF $NO_x$ SOURCES

| SCC Code | Category | Number |
|---|---|---|
| 1-01 | Boilers, Electric generation | 22 |
| 1-02 | Boilers, Industrial | 2 |
| 3-05 | Industrial - Cement | 1 |
| 3-06 | Industrial - Petroleum | 1 |

TABLE 11. CLASSIFICATION OF HYDROCARBON SOURCES

| SCC Code | Category | | Number* |
|---|---|---|---|
| 1-01 | Boilers, Electric Generation | (0) | 9 |
| 2-01 | Internal Comb., Turbine | (0) | 2 |
| 3-01 | Chemical Industry | (1) | 4 |
| 3-03 | Primary Metals - Coking | (1) | 2 |
| 3-06 | Petroleum Industry - Processing | (4) | 17 |
| 4-03 | - Evaporation | (11) | 44 |
| 4-02 | Surface Coating - Evaporation | (6) | 19 |
| 5-01 | Municip. Incinerator | (0) | 2 |

*Bracketed numbers are sources in excess of 1000 tons/year; unbracketed are sources greater than 100 tons/year.

The significance of the high percentage of power boilers lies in the fact that data pertaining to boiler operations are usually well kept and more readily available than data about process operations. Since $SO_2$ emissions can be calculated readily from fuel consumption and analysis figures, and the emissions of other pollutants are closely related to fuel consumption and operating conditions, the acquisition of hourly fuel consumption data will go a long way toward the creation of an hourly emission inventory. For this reason, considerable emphasis was placed on the acquisition of hourly fuel consumption (and related data), particularly in the early stages of the RAPS inventory effort.

### 7.2.2 Operating Data

This group includes all those point emission sources which are either minor (emitting less than 1000 tons/year) or for which no detailed hourly data are available.

The emissions from smaller sources is recorded as annual data, together with the operating patterns. The pattern is capable of indicating the actual operating hours, operating days (in Julian form) and weekly patterns by days. For example, the entry

D:2-48, 50-184, 186-244, 246-365, W:1-5, H:8-17

denotes the operation of a plant which normally operates Monday through Friday (W:1-5), from 8 AM to 5 PM (H:8-17), but is closed down for New Year's (D:1), Washington's Birthday (D:49), Independence Day (D:185), and Labor Day (D:245). If an hourly output for a specific hour and day is requested, the computer will first make sure the plant was operating that day, then divide the annual number by the actual number of hours of operation for a 5 day week, 9 hours a day operation, less the number of days when the plant was shut down.

### 7.2.3 Stack Gas Measurements

The RAPS emission inventory should ideally contain direct statements of weight of pollutants emitted from each major source as a function of location for every hour. The most direct way to acquire this information would appear to be monitor stack emissions.

In actuality, emissions (in terms of weight of pollutant) cannot be directly measured. Stack gas analyzers only provide a measure of the concentration of the pollutant, thus requiring another measurement--stack gas volume--before the weight of the emitted pollutant can be determined. Stack gas volume, in turn, is not measured directly, but rather is determined by measuring the gas velocity by traversing the cross-section of the stack. From the average velocity and the known dimension of the stack, the volume of the stack gases can be calculated. In addition, the molecular weight of the sampled gas has to be determined to obtain the mass flow rate. Thus, the seemingly direct and straight-forward approach to the determination of pollutant emissions by stack analysis actually consists of a number of measurements, manipulations and calculations, each of which contributes to the accuracy of the final figure.

Stack sampling methods for compliance purposes have been standardized. EPA methods are described in CFR Title 40 (Protection of Environment) as an appendix to paragraph 60.85. The methods are:

Method 1: Sample and Velocity Traverses for Stationary Sources
Method 3: Gas Analyses for $CO_2$, Excess Air and Dry Molecular Weight
Method 4: Determination of Moisture in Stack Gases
Method 5: Determination of Particulate Emissions from Stationary Sources
Method 6: Determination of $SO_2$ Emissions from Stationary Sources
Method 7: Determination of $NO_X$ Emissions from Stationary Sources
Method 8: Determination of Sulfuric Acid Mist and $SO_2$ from Stationary Sources
Method 9: Visual Determination of Opacity of Emissions from Stationary Sources

Stack sampling is time consuming and expensive; for this reason, it is used only to provide a primary calibration of emission factors which are used in conjunction with more readily accessible data, such as fuel consumption or processing rates. The most extensive collection of emission factors is contained in EPA's "Compilation of Air Pollutant Emission Factors" (AP-42) which is in almost universal use. Nevertheless, emission factors contained there are averages and vary widely in accuracy. They are rated for estimated accuracy on a scale ranging from "A" to "E", depending on the number and quality of field measurements on which they are based.

To insure the accuracy of the RAPS emission inventory, some stack testing was planned. Such testing should include at least one example in each SCC category; if budgetary constraints permit, a considerable number of important sources should be sampled individually (the SRI report (2) suggests a total of 65 stack tests). Tables 12 and 13 show the distribution of the major sources by SCC categories.

By combining similar sources and matching categories with actual sources in the St. Louis AQCR, the following minimum schedule (Table 14) was determined if at least one installation of each type is to be represented. The total of 17 stack tests should really be considered as a "Phase 1" program, to be supplemented by further tests based on inspection and review of existing facilities.

As discussed above, $SO_2$ is the one pollutant for which adequate data can be obtained with only minimal stack testing, at least for those facilities which do not have any stack gas cleaning (scrubbing) equipment. At present, none of the boilers are equipped with such scrubbers; experimental work is being conducted with a "Catox" unit at the Wood River power plant.

Though fuel consumption and process data are potentially capable of providing quite accurate $SO_2$ emission figures, sampling for sulfur analysis has to be adequately performed. Practices vary widely; some plants have continuous, automatic samplers, but these are located at the coal-pile end of the conveyor system. Since there are usually storage bins in the boiler-house itself, there is an 8 to 12 hour lag between the sample and the material burned. Most plants sample only intermittently--once a shift, once a day, even once for each barge. Fortunately, the sulfur analysis of coal does seem to be fairly constant (about ± 10%). A statistical evaluation of the sampling procedures is planned; the time lag will be incorporated in the calculations.

Accurate data for $NO_X$ have to be based almost wholly on stack testing. The EPA emission factors span a range of 3 to 55 pounds of $NO_X$ per ton of coal, and 40 to 105 pounds of $NO_X$ per $10^3$ gallons of oil.

TABLE 12. DISTRIBUTION OF LARGE SOURCES IN THE ST. LOUIS AQCR BY SCC CODES

External Combustion Boilers

| SCC Code | Description | | Number |
|---|---|---|---|
| 1-01-002-01 | Elect. Gen., Bitum. Coal, > 100 x $10^6$ Btu/hr. | Pulv., wet | 7 |
| 1-01-002-02 | | Pulv., dry | 14 |
| 1-01-002-03 | | Cyclone | 4 |
| 1-01-002-08 | | Stoked | 1 |
| 1-02-002-01 | Industrial, Bitum. Coal, > 100 x $10^6$ Btu/hr. | Pulv., wet | 1 |
| 1-02-002-02 | | Pulv., dry | 3 |
| 1-02-002-04 | | Stoked | 5 |
| 1-02-002-09 | | Stoked | 5 |
| 1-02-004-01 | Residual Oil | | 4 |
| 1-02-004-02 | Residual Oil | | 1 |

TABLE 13. DISTRIBUTION OF LARGE SOURCES IN THE ST. LOUIS AQCR BY SCC CODES

Process Heaters & Processing Emissions

| SCC Code | Description | | | Number |
|---|---|---|---|---|
| 3-01-023-99 | Industrial Process | Chemical Mfg. | $H_2SO_4$-Contact | 2 |
| 3-01-999-99 | | | Miscellaneous* | 2 |
| 3-03-010-01 | | | Lead Smelter | 1 |
| 3-04-004-03 | | Secondary Metal | Lead Smelter | 1 |
| 3-06-001-03 | | Petroleum Ind. | Process Heater, Oil | 2 |
| 3-06-001-14 | | | , Gas | 4 |
| 3-06-002-01 | | | Fluid Crackers | 4 |
| 3-06-999-98 | | | Miscellaneous | 1 |

*using special emission factors

### TABLE 14. MINIMUM TEST SCHEDULE

A. POWER GENERATION

| Equipment | | | Fuel | | Firing Mode | Minimum No. of Tests | Suggested Location |
|---|---|---|---|---|---|---|---|
| Ext. | Combust. | Boiler | Bitum. | Coal | Stoked | 2 | Monsanto |
| " | " | " | " | " | Pulverized | 2 | Wood River-Labadie |
| " | " | " | " | " | Cyclone | 2 | Sioux-Baldwin |
| " | " | " | Oil | | | 1 | Shell Oil |
| | | | | | | 7 | |

B. INDUSTRIAL SOURCES

| Industry | Type | Minimum No. of Tests | Suggested Location |
|---|---|---|---|
| Chemical Industry | Sulfuric Acid | 1 | N.L. |
| | Miscellaneous | 2 | Monsanto-Anlin |
| Prim. & Sec. Metals | - | 2 | St. Joseph |
| Petroleum | Heaters | 2 | Shell-Amoco |
| | Crackers | 2 | Shell-Amoco |
| | Others | 1 | Amoco |
| | | 10 | |

## 8.0 DATA HANDLING

As indicated in Section 7.2.1, emission (or emission related) data are provided in many different forms, ranging from computer printouts to strip or circular charts. The raw data have to be tabulated in appropriate form before entry into the RAPS computer bank.

A data handling system (System 2000) had been selected which is capable of storing data elements of variable length in repeating groups. The repeating groups define the structure for storing multiple sets of data values and link the hierarchical levels.

Data preparation forms will be designed to aid the data clerk in the structuring of the data and to make it easier to use the correct syntax. It will not be possible, however, to depend only on well-designed data preparation forms for data quality because the content as well as the form of the data must be verified.

Data verification can be carried out in part by the data management system, using a preliminary storage file which can be verified, proofread and corrected before the data manager decides that it is accurate enough to merge into the main file.

A detailed instruction sheet has to be prepared for each data sheet for the guidance of the data clerk. This sheet stipulates the units (if not indicated on the original record) and specifies the manipulations, if any, which had to be performed to obtain hourly data which could be fed into the computerized RAPS inventory. In order to avoid human error as far as possible, only a minimum of handling will be carried out. For example, data will be recorded in whatever unit they were supplied and the units made part of the record. Transformation into standardized units could then be performed by the retrieval program to meet the specific needs of the user.

For most actual sources, the values stored will be consumption or other source data, rather than measured values of emission. The format was to accommodate emission or consumption data. For those sources for which there are no direct emission data, emissions must be calculated using emission factors. The emission inventory software system will be capable of assessing the consumption data element, refer to the appropriate code, look up the emission factor, and compute the emission values for each specified set of pollutants.

## B. RAPS POINT SOURCE EMISSION INVENTORY

## 1.0 DATA ACQUISITION

As outlined in the methodology, hourly measured data of emission related parameters were required for all major sources.

To test the feasibility of this approach, appropriate officials of nine of the 15 companies emitting more than 1000 tons/year (shown in Table 3) were contacted and interviewed. These included Union Electric, Illinois Power, St. Joseph Lead, Alton Box Board, Laclede Steel, Monsanto Chemicals, Anheuser-Busch, Shell Oil Company, and Amoco Oil. These nine companies were responsible for over 90% of the total $SO_2$ emitted from point sources in the St. Louis area; this included the utility companies, who were emitting approximately 85% of all the $SO_2$ in the area. All but two agreed to supply the necessary hourly data to RAPS (later on, information was obtained from these companies, too). Thus, even if the percentage of cooperation of the smaller companies should drop off, it appeared that measured data for at least 90% of the total emission of $SO_2$ would be available. The accuracy of these data is of the order of the accounting procedures used by the companies, which is higher than that of chemical analysis.

### 1.1 MAJOR AND MINOR SOURCES

Ultimately, hourly data were obtained from 14 companies, annual data from another 85. The breakdown is shown in Tables 15 and 16. Figure 4 shows the location of the major sources in the St. Louis area. Appendix B lists the Plant and Point ID's and SCC codes for the sources in RAPS containing hourly data and annual work patterns.

The following information was then secured at the operating level:

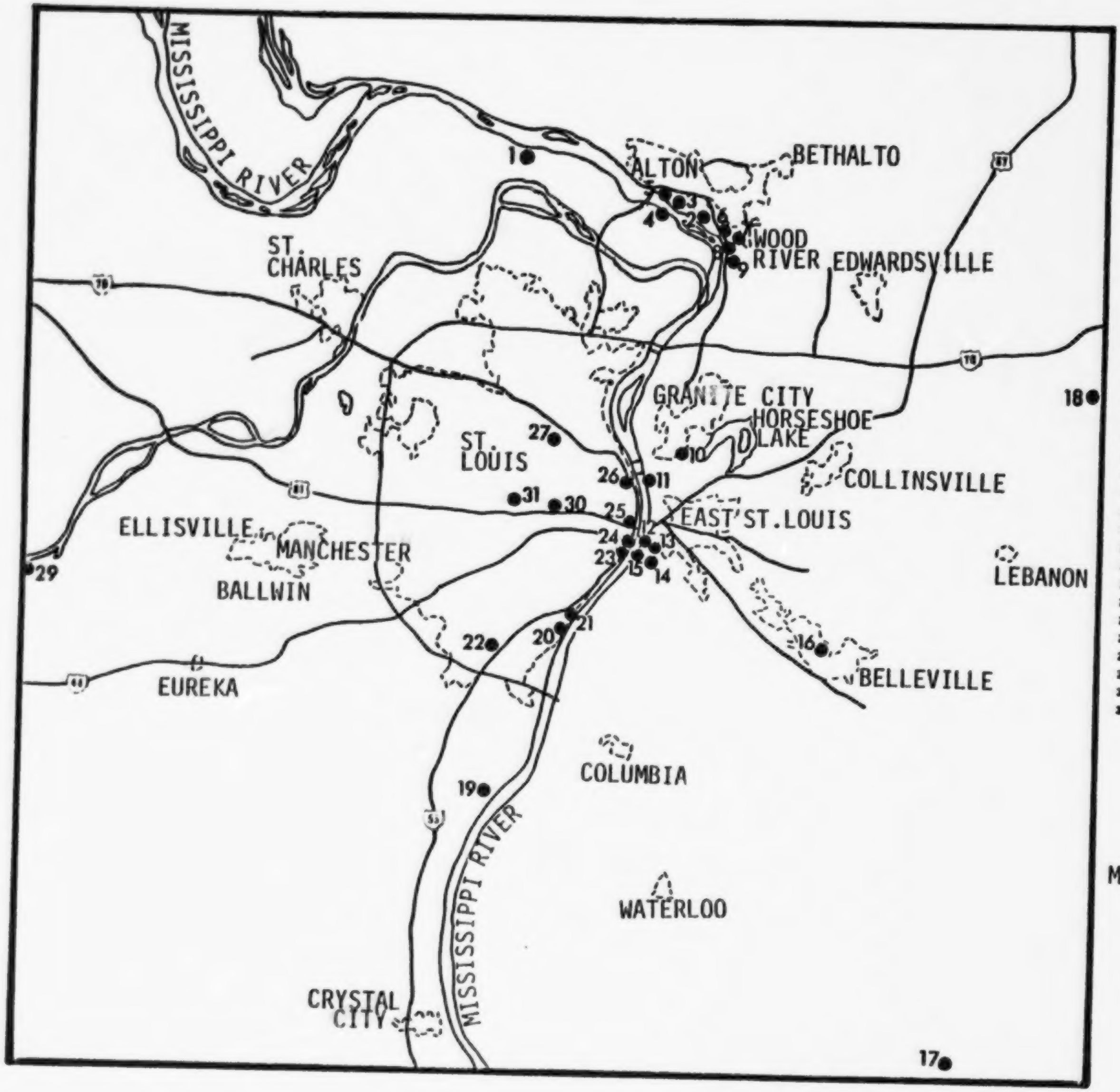
1. Source Description: address, location (by UTM coordinates), type of operation (SIC and SCC Codes), etc. Most of this information was available in the NEDS printout but had to be verified (particularly location, which should be to ± 0.01 km).

TABLE 15. HOURLY POINT SOURCE SUMMARY

| Companies | Locations | Number of Point Sources | | | | | |
|---|---|---|---|---|---|---|---|
| | | Part. | $SO_2$ | $NO_X$ | HC | CO | Heat |
| 14 | 22 | 113 | 146 | 113 | 113 | 82 | 113 |

TABLE 16. ANNUAL POINT SOURCE SUMMARY

| Companies | Locations | Number of Point Sources | | | | | |
|---|---|---|---|---|---|---|---|
| | | Part. | $SO_2$ | $NO_X$ | HC | CO | Heat |
| 85 | 92 | 204 | 128 | 121 | 285 | 123 | 132 |


MISSISSIPPI RIVER
ALTON
BETHALTO
WOOD RIVER
EDWARDSVILLE
ST. CHARLES
GRANITE CITY
HORSESHOE LAKE
COLLINSVILLE
ST. LOUIS
EAST ST. LOUIS
ELLISVILLE
MANCHESTER
BALLWIN
LEBANON
BELLEVILLE
EUREKA
COLUMBIA
WATERLOO
CRYSTAL CITY
MISSISSIPPI RIVER
1
2
3
4
5
6
7
8
9
10
11
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31

| MAP NO. | SOURCE | APPROX. TON/YR $SO_2$ |
|---|---|---|
| 1 | Union Electric – Sioux | 116,000 |
| 2 | Illinois Power – Wood River | 73,000 |
| 3 | Laclede Steel | 375 |
| 4 | Alton Box Board | 13,000 |
| 5 | Owens Illinois Glass | 300 |
| 6 | Amoco Oil Refinery | 12,000 |
| 7 | Shell Oil Refinery | 30,000 |
| 8 | Anlin Co. | 2,500 |
| 9 | Clark Oil Refinery | 6,000 |
| 10 | Granite City Steel | 2,000 |
| 11 | Union Electric – Venice | 25,000 |
| 12 | AMAX Zinc | 1,500 |
| 13 | Edwin Cooper | 800 |
| 14 | Monsanto – WG Krummrich | 12,000 |
| 15 | Union Electric – Cahokia | 10,000 |
| 16 | Stag Brewery | 800 |
| 17 | Illinois Power – Baldwin | 200,000 |
| 18 | Highland Electric | 1,400 |
| 19 | Union Electric – Meramec | 60,000 |
| 20 | N.L. Industries | 8,000 |
| 21 | Great Lakes Carbon | 700 |
| 22 | Alpha Cement | 600 |
| 23 | Anheuser Busch | 2,500 |
| 24 | Monsanto – J F Queeny | 2,000 |
| 25 | Union Electric – Ashley | 4,600 |
| 26 | PVO Int. | 1,500 |
| 27 | General Motors | 1,600 |
| 28 | Missouri Portland | 900 |
| 29 | Union Electric – Labadie | 200,000 |
| 30 | Washington Univ. – Euclid Sta. | 660 |
| 31 | Washington Univ. – Campus | 360 |

FIGURE 4. RAPS
MAJOR POINT SOURCES

2. Data: pollutant concentration in stack, quantity and type of fuel burned, amount of steam or power produced, fuel analysis, process
3. Collection of Data: data collection was arranged so as to minimize the effort required by the affected companies. Data were usually mailed to Rockwell once a month.

The actual data obtained covered a wide range of formats, from computer printouts of hourly fuel consumption to strip and circular charts, and even entries in logbooks. As an example, Figure 5 shows a computer printout for the Baldwin Power plant, which gives hourly coal consumption figures. Figure 6 shows load data in megawatts for each boiler. Figure 7 shows a steam abort for an industrial boiler. Figure 8 gives a tabulation of $SO_2$ concentration values for a sulfuric acid plant. Figure 9 gives a daily log for a refinery boiler which used several types of fuel.

## 1.2 INDUSTRIAL AREA SOURCES

Major Stationary Point Sources include all sources which individually contribute more than about 0.1% of the total emissions of a given pollutant; Minor Sources, for which less detailed data were obtained, includes sources emitting more than 0.01% of a given pollutant.

The remaining point sources were assigned to the appropriate grid square and considered part of the Area Source inventory. However, since no reasonable distribution function for those small industrial sources could be developed, they were actually treated similarly to "minor sources", that is, annual operating data and individual emission data were obtained for all of these sources. For this reason, they are included in this report.

The first step in inventorying these sources consisted of the preparation of a cross-referenced list of the companies involved. This was followed up by actual contact with the appropriate officials to obtain current consumption or process rates as well as work patterns.

For the purposes of the industrial area emission inventory a source is an individual company. By the term "company" is meant a plant location of industrial character which is treated as a separate entity. Annual 1975

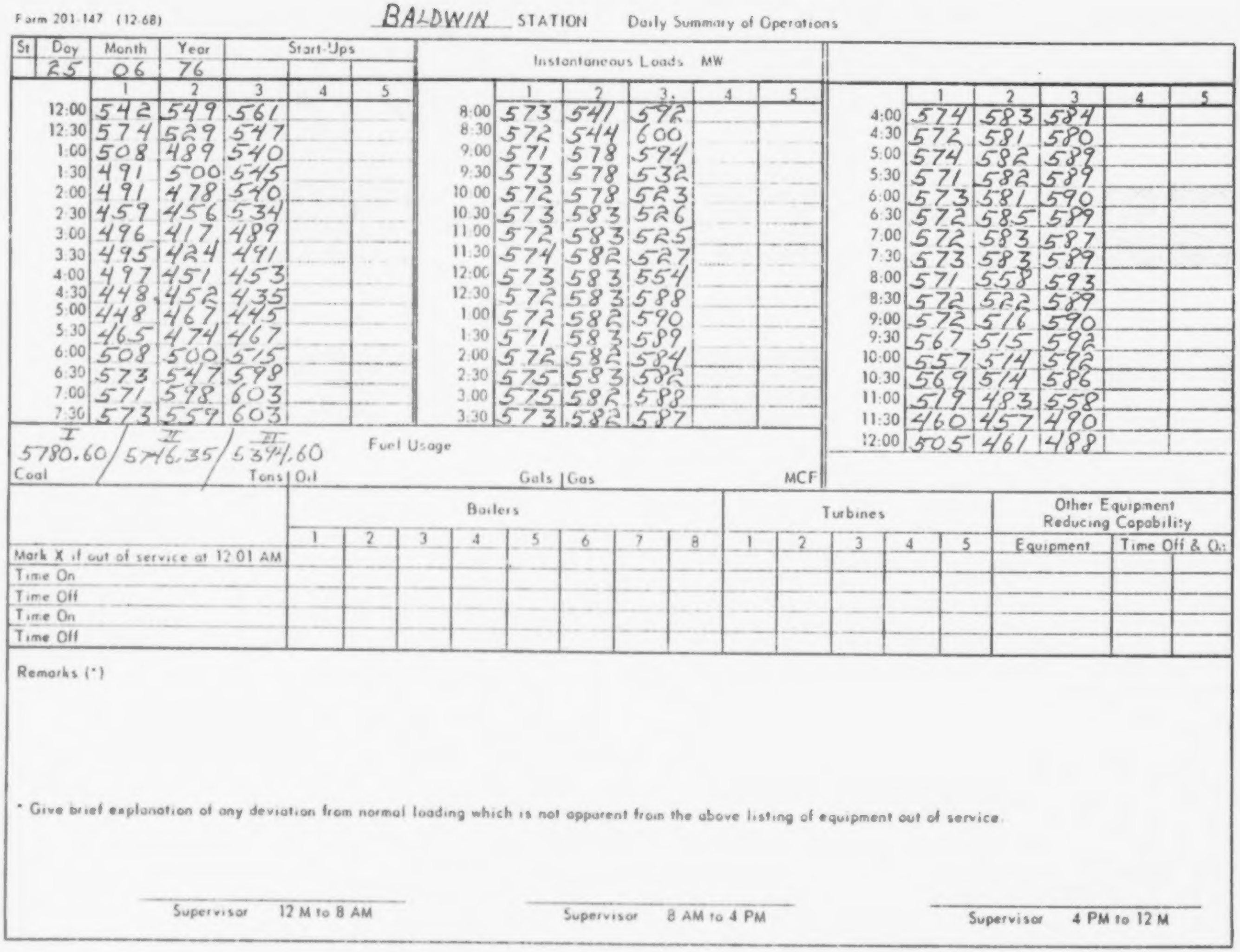
```
                                          PERIODIC LO
                         BALDWIN STATION UNIT 3 ILLIN IS POWER COMPANY

04-21-76
************************************************************* **************************************
     T    FUEL    *        FLUE GAS                         *  AIR AN  FLUE GAS TEMP              *
TIME Y ****************************************************** ******************************* AH3A AH3B
     P  COAL    OIL  SO2  FURN    FURN    AH3A   AH3B   O2   AH3A AH  A AH3A AH3A AH3B AH3B AH3B AH3B COLD COLD
     E  FLOW    TO   IN   -RH     TOECON  DP FG  DP FG  IN   AIR  AI    GAS  GAS  AIR  AIR  GAS  GAS
     O          BNRS FG   OUT DP  OUT DP  SIDE   SIDE   FG   IN   OU    IN   OUT  IN   OUT  IN   OUT  TEMP TEMP
     F  KLBS    KGAL PPM  INWC    INWC    INWC   INWC   %    F    F     F    F    F    F    F    F    F    F
**** L ****************************************************** **************************************
     O  4165    3064 1103 1088    1093    3093   3094   3054 1570 15 1 1572 1573 1576 1577 1578 1579 1574 1575
**** G ****************************************************** **************************************

0100 H  398.20  0.6       -2.1    -4.2    2.1    2.0    3.8  173  48    547  276  168  501  554  277  56   54
0200 H  376.49  0.7       -2.0    -3.7    1.7    1.6    3.9  173  48    538  274  167  494  543  273  56   54
0300 H  371.89  0.5       -2.0    -3.6    1.6    1.5    3.8  174  48    536  273  168  492  541  272  56   54
0400 H  360.00  0.5       -2.0    -3.5    1.5    1.5    4.2  173  47    530  272  167  487  535  271  55   53
0500 H  368.39  0.4       -2.0    -3.7    1.6    1.6    4.2  175  47    533  273  169  488  538  271  56   53
0600 H  384.09  0.5       -2.1    -4.0    1.9    2.0    4.3  172  48    546  274  167  497  552  274  56   54
0700 H  429.29  0.6       -2.1    -4.7    2.5    2.5    4.0  172  49    556  275  167  501  561  275  56   54
0800 H  493.49  0.4       -2.2    -5.8    3.5    3.3    3.6  170  50    578  280  165  516  584  282  56   54
0900 H  507.69  0.4       -2.2    -5.9    3.5    3.3    4.4  150  50    582  272  145  519  589  274  53   51
1000 H  515.69  0.5       -2.3    -6.2    3.6    3.5    3.7  123  50    586  253  119  518  596  257  47   45
1100 H  519.99  0.5       -2.3    -6.3    3.8    3.8    3.7  122  50    592  253  118  521  601  257  47   45
1200 H  520.39  0.4       -2.4    -6.4    3.8    3.9    3.7  124  50    588  253  121  519  598  258  47   46
1300 H  518.59  0.4       -2.4    -6.4    3.8    4.0    3.7  125  50    593  255  121  525  605  261  47   46
1400 H  520.39  0.5       -2.5    -6.5    3.7    4.0    3.7  124  50    594  255  120  527  607  261  47   46
1500 H  519.49  0.4       -2.5    -6.5    3.6    4.0    3.6  122  51    595  254  119  528  608  261  47   46
1600 H  516.59  0.4       -2.5    -6.5    3.4    4.0    3.6  120  51    595  254  117  528  609  259  47   45
1700 H  507.99  0.4       -2.5    -6.2    3.2    3.9    3.7  125  50    588  256  122  524  601  261  48   46
1800 H  509.09  0.4       -2.5    -6.2    3.3    3.8    3.6  141  50    588  266  138  524  600  271  51   49
1900 H  510.39  0.4       -2.5    -6.2    3.7    3.8    3.4  150  50    587  271  147  525  599  275  53   51
2000 H  510.59  0.4       -2.5    -6.2    3.7    3.7    3.5  168  51    587  283  164  529  600  287  56   55
2100 H  510.69  0.5       -2.5    -6.2    3.7    3.7    3.4  167  51    588  283  163  531  602  288  56   55
2200 H  506.09  0.5       -2.6    -6.2    3.3    3.6    3.4  165  51    586  282  161  529  600  287  56   54
2300 H  492.99  0.5       -2.5    -5.9    2.9    3.5    3.4  165  51    582  282  161  530  598  287  56   54
2400 H  446.39  0.6       -2.4    -5.0    2.0    2.7    3.6  168  50    567  279  163  521  582  284  56   54

2400 D  11315   12       0-2.3    -5.5    3.0    3.1    3.8  152  50    573  269  147  516  584  272  52   51
```

FIGURE 5. INPUT DATA: PRINTOUT OF HOURLY DATA



Form 201-147 (12-68) BALDWIN STATION Daily Summary of Operations

| St | Day | Month | Year | Start-Ups | | |
|---|---|---|---|---|---|---|
| | 25 | 06 | 76 | | | |

Instantaneous Loads MW

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 12:00 | 542 | 549 | 561 | | |
| 12:30 | 574 | 529 | 547 | | |
| 1:00 | 508 | 489 | 540 | | |
| 1:30 | 491 | 500 | 545 | | |
| 2:00 | 491 | 478 | 540 | | |
| 2:30 | 459 | 456 | 534 | | |
| 3:00 | 496 | 417 | 489 | | |
| 3:30 | 495 | 424 | 491 | | |
| 4:00 | 497 | 451 | 453 | | |
| 4:30 | 448 | 452 | 435 | | |
| 5:00 | 448 | 467 | 445 | | |
| 5:30 | 465 | 474 | 467 | | |
| 6:00 | 508 | 500 | 515 | | |
| 6:30 | 573 | 547 | 598 | | |
| 7:00 | 571 | 598 | 603 | | |
| 7:30 | 573 | 559 | 603 | | |

| | 1 | 2 | 3. | 4 | 5 |
|---|---|---|---|---|---|
| 8:00 | 573 | 541 | 592 | | |
| 8:30 | 572 | 544 | 600 | | |
| 9:00 | 571 | 578 | 594 | | |
| 9:30 | 573 | 578 | 532 | | |
| 10:00 | 572 | 578 | 523 | | |
| 10:30 | 573 | 583 | 526 | | |
| 11:00 | 572 | 583 | 525 | | |
| 11:30 | 574 | 582 | 527 | | |
| 12:00 | 573 | 583 | 554 | | |
| 12:30 | 572 | 583 | 588 | | |
| 1:00 | 572 | 582 | 590 | | |
| 1:30 | 571 | 583 | 589 | | |
| 2:00 | 572 | 582 | 584 | | |
| 2:30 | 575 | 583 | 582 | | |
| 3:00 | 575 | 582 | 588 | | |
| 3:30 | 573 | 582 | 587 | | |

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 4:00 | 574 | 583 | 584 | | |
| 4:30 | 572 | 581 | 580 | | |
| 5:00 | 574 | 582 | 589 | | |
| 5:30 | 571 | 582 | 589 | | |
| 6:00 | 573 | 581 | 590 | | |
| 6:30 | 572 | 585 | 589 | | |
| 7:00 | 572 | 583 | 587 | | |
| 7:30 | 573 | 583 | 589 | | |
| 8:00 | 571 | 558 | 593 | | |
| 8:30 | 572 | 522 | 589 | | |
| 9:00 | 572 | 516 | 590 | | |
| 9:30 | 567 | 515 | 592 | | |
| 10:00 | 557 | 514 | 592 | | |
| 10:30 | 569 | 514 | 586 | | |
| 11:00 | 519 | 483 | 558 | | |
| 11:30 | 460 | 457 | 490 | | |
| 12:00 | 505 | 461 | 488 | | |

Fuel Usage

I 5780.60 / II 5746.35 / III 5394.60

Coal Tons | Oil Gals | Gas MCF

| | Boilers | | | | | | | | Turbines | | | | | Other Equipment Reducing Capability | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | Equipment | Time Off & On | |
| Mark X if out of service at 12:01 AM | | | | | | | | | | | | | | | | |
| Time On | | | | | | | | | | | | | | | | |
| Time Off | | | | | | | | | | | | | | | | |
| Time On | | | | | | | | | | | | | | | | |
| Time Off | | | | | | | | | | | | | | | | |

Remarks (*)

* Give brief explanation of any deviation from normal loading which is not apparent from the above listing of equipment out of service.

Supervisor 12 M to 8 AM

Supervisor 8 AM to 4 PM

Supervisor 4 PM to 12 M

FIGURE 6. INPUT DATA: SUMMARY OF LOAD DATA

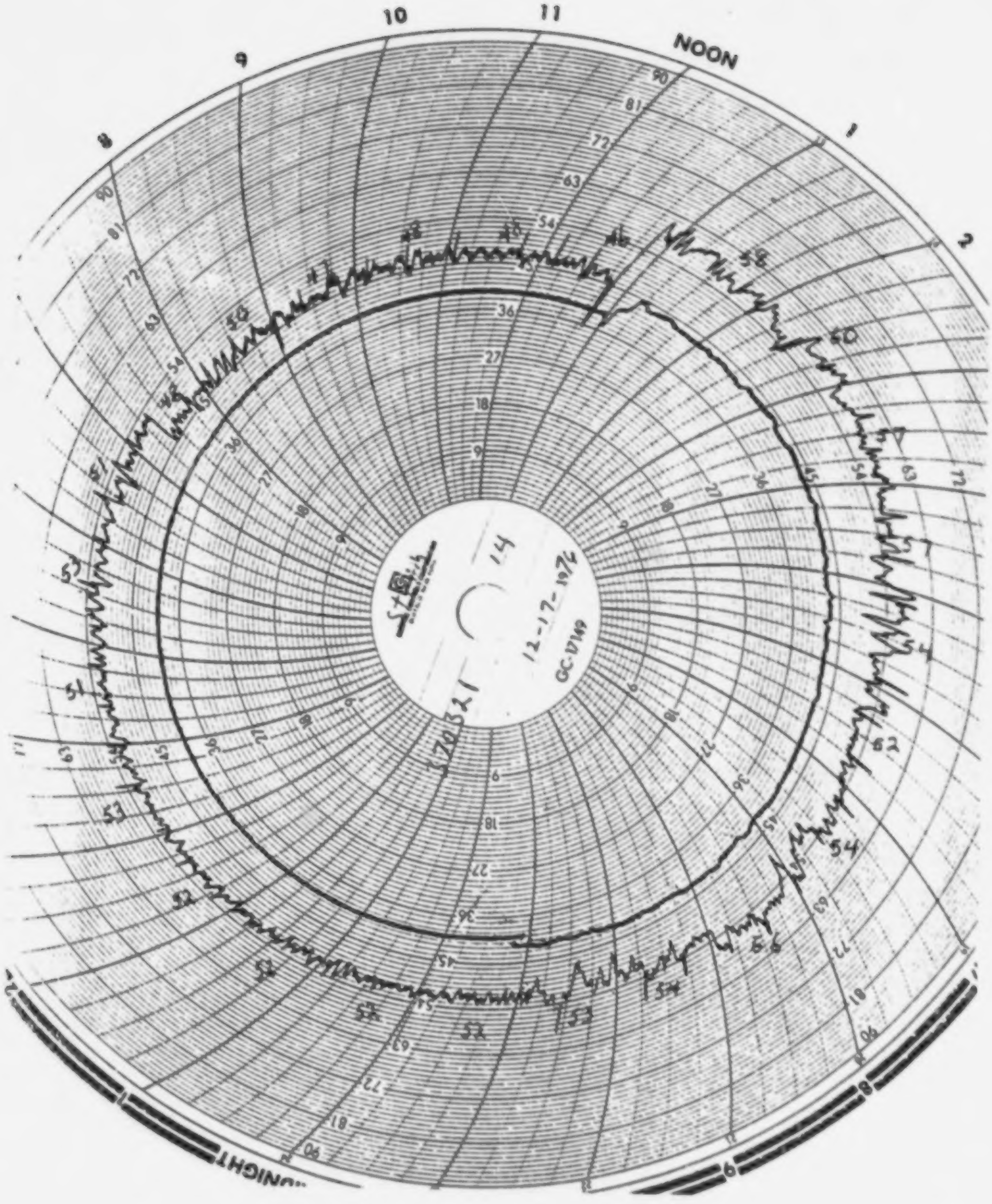
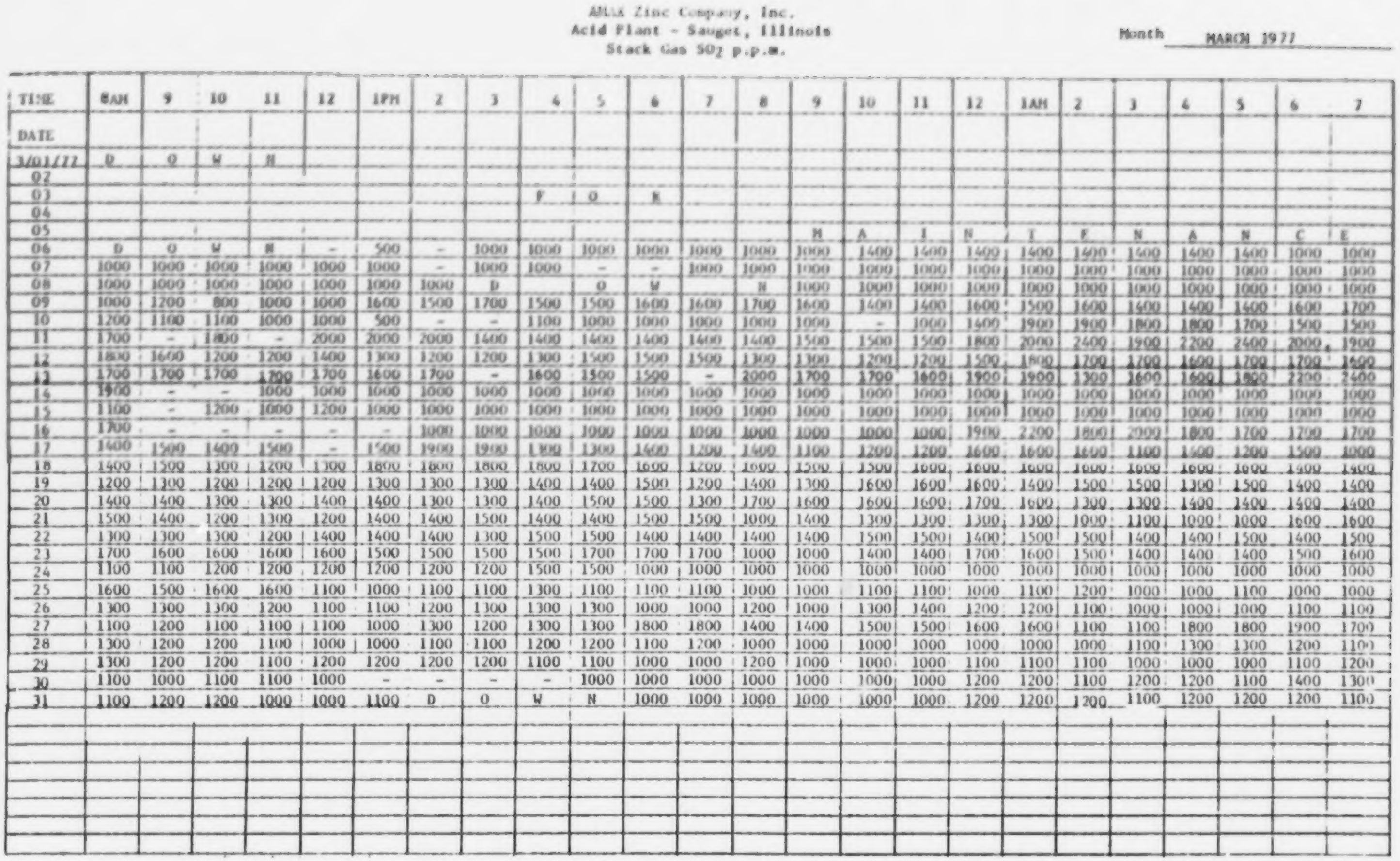


FIGURE 7. INPUT DATA: STEAM CHART

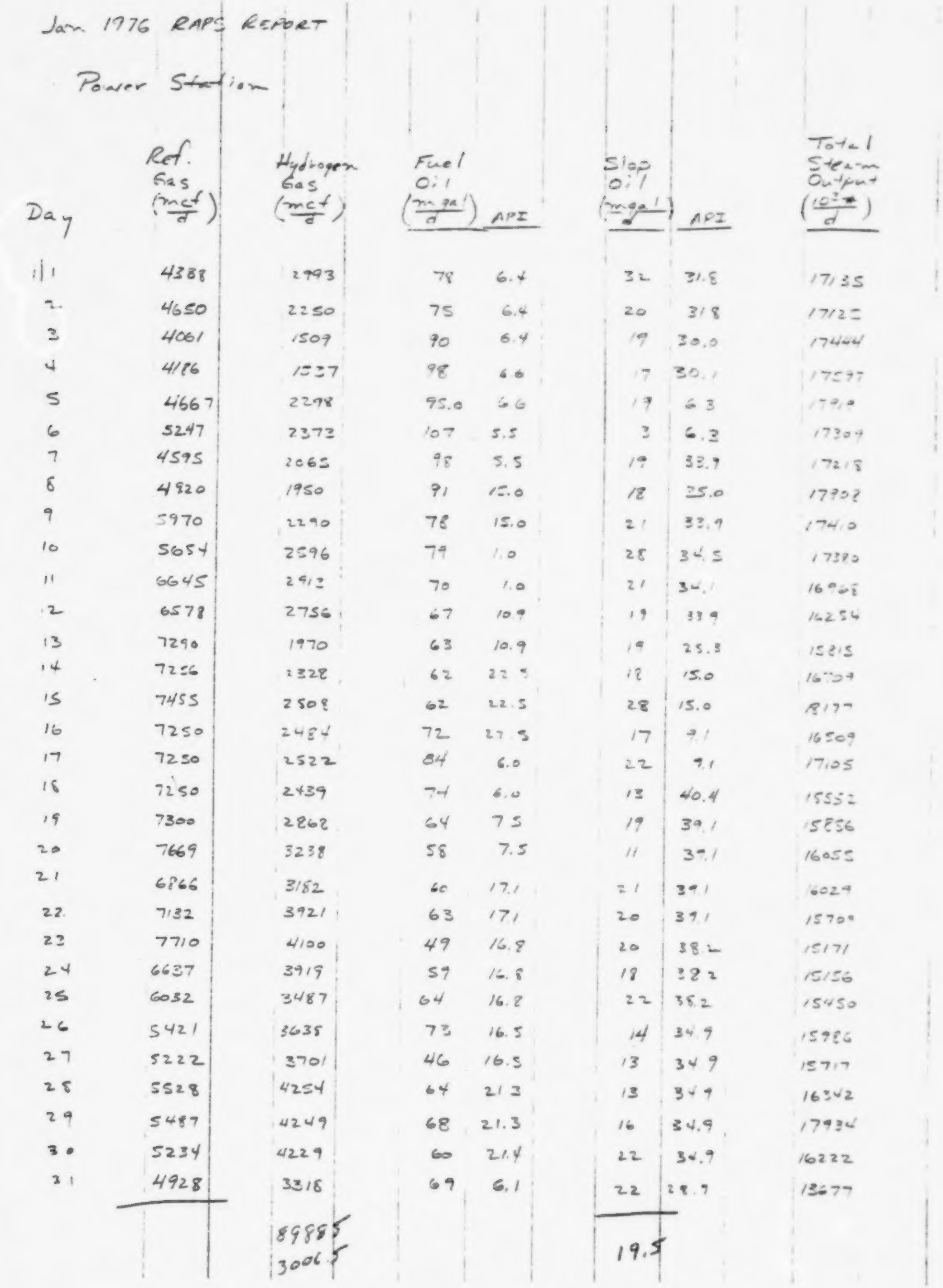


AMAX Zinc Company, Inc.
Acid Plant - Sauget, Illinois
Stack Gas $SO_2$ p.p.m.

Month MARCH 1977

| TIME | 8AM | 9 | 10 | 11 | 12 | 1PM | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1AM | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | | | | | | | | | | | | | | | | | | | | | | | | |
| 3/01/77 | D | O | W | N | | | | | | | | | | | | | | | | | | | | |
| 02 | | | | | | | | | | | | | | | | | | | | | | | | |
| 03 | | | | | | | | | F | O | R | | | | | | | | | | | | | |
| 04 | | | | | | | | | | | | | | | | | | | | | | | | |
| 05 | | | | | | | | | | | | | | M | A | I | N | T | E | N | A | N | C | E |
| 06 | D | O | W | N | - | 500 | - | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1000 | 1000 |
| 07 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | - | 1000 | 1000 | - | - | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 08 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | D | | O | W | | N | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 09 | 1000 | 1200 | 800 | 1000 | 1000 | 1600 | 1500 | 1700 | 1500 | 1500 | 1600 | 1600 | 1700 | 1600 | 1400 | 1400 | 1600 | 1500 | 1600 | 1400 | 1400 | 1400 | 1600 | 1700 |
| 10 | 1200 | 1100 | 1100 | 1000 | 1000 | 500 | - | - | 1100 | 1000 | 1000 | 1000 | 1000 | 1000 | - | 1000 | 1400 | 1900 | 1900 | 1800 | 1800 | 1700 | 1500 | 1500 |
| 11 | 1700 | - | 1800 | - | 2000 | 2000 | 2000 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1500 | 1500 | 1500 | 1800 | 2000 | 2400 | 1900 | 2200 | 2400 | 2000 | 1900 |
| 12 | 1800 | 1600 | 1200 | 1200 | 1400 | 1300 | 1200 | 1200 | 1300 | 1500 | 1500 | 1500 | 1300 | 1300 | 1200 | 1200 | 1500 | 1800 | 1700 | 1700 | 1600 | 1700 | 1700 | 1600 |
| 13 | 1700 | 1700 | 1700 | 1700 | 1700 | 1600 | 1700 | - | 1600 | 1500 | 1500 | - | 2000 | 1700 | 1700 | 1600 | 1900 | 1900 | 1300 | 1600 | 1600 | 1800 | 2200 | 2400 |
| 14 | 1900 | - | - | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 15 | 1100 | - | 1200 | 1000 | 1200 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 16 | 1700 | - | - | - | - | - | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1900 | 2200 | 1800 | 2000 | 1800 | 1700 | 1700 | 1700 |
| 17 | 1600 | 1500 | 1400 | 1500 | - | 1500 | 1900 | 1900 | 1300 | 1300 | 1600 | 1200 | 1600 | 1100 | 1200 | 1200 | 1600 | 1600 | 1600 | 1100 | 1600 | 1200 | 1500 | 1000 |
| 18 | 1400 | 1500 | 1300 | 1200 | 1300 | 1800 | 1800 | 1800 | 1800 | 1700 | 1600 | 1200 | 1600 | 1500 | 1500 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1400 | 1400 |
| 19 | 1200 | 1300 | 1200 | 1200 | 1200 | 1300 | 1300 | 1300 | 1400 | 1400 | 1500 | 1200 | 1400 | 1300 | 1600 | 1600 | 1600 | 1400 | 1500 | 1500 | 1300 | 1500 | 1400 | 1400 |
| 20 | 1400 | 1400 | 1300 | 1300 | 1400 | 1400 | 1300 | 1300 | 1400 | 1500 | 1500 | 1300 | 1700 | 1600 | 1600 | 1600 | 1700 | 1600 | 1300 | 1300 | 1400 | 1400 | 1400 | 1400 |
| 21 | 1500 | 1400 | 1200 | 1300 | 1200 | 1400 | 1400 | 1500 | 1400 | 1400 | 1500 | 1500 | 1000 | 1400 | 1300 | 1300 | 1300 | 1300 | 1000 | 1100 | 1000 | 1000 | 1600 | 1600 |
| 22 | 1300 | 1300 | 1300 | 1200 | 1400 | 1400 | 1400 | 1300 | 1500 | 1500 | 1400 | 1400 | 1400 | 1400 | 1500 | 1500 | 1400 | 1500 | 1500 | 1400 | 1400 | 1500 | 1400 | 1500 |
| 23 | 1700 | 1600 | 1600 | 1600 | 1600 | 1500 | 1500 | 1500 | 1500 | 1700 | 1700 | 1700 | 1000 | 1000 | 1400 | 1400 | 1700 | 1600 | 1500 | 1400 | 1400 | 1400 | 1500 | 1600 |
| 24 | 1100 | 1100 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1500 | 1500 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 25 | 1600 | 1500 | 1600 | 1600 | 1100 | 1000 | 1100 | 1100 | 1300 | 1100 | 1100 | 1100 | 1000 | 1000 | 1100 | 1100 | 1000 | 1100 | 1200 | 1000 | 1000 | 1100 | 1000 | 1000 |
| 26 | 1300 | 1300 | 1300 | 1200 | 1100 | 1100 | 1200 | 1300 | 1300 | 1300 | 1000 | 1000 | 1200 | 1000 | 1300 | 1400 | 1200 | 1200 | 1100 | 1000 | 1000 | 1000 | 1100 | 1100 |
| 27 | 1100 | 1200 | 1100 | 1100 | 1100 | 1000 | 1300 | 1200 | 1300 | 1300 | 1800 | 1800 | 1400 | 1400 | 1500 | 1500 | 1600 | 1600 | 1100 | 1100 | 1800 | 1800 | 1900 | 1700 |
| 28 | 1300 | 1200 | 1200 | 1100 | 1000 | 1000 | 1100 | 1100 | 1200 | 1200 | 1100 | 1200 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1100 | 1300 | 1300 | 1200 | 1100 |
| 29 | 1300 | 1200 | 1200 | 1100 | 1200 | 1200 | 1200 | 1200 | 1100 | 1100 | 1000 | 1000 | 1200 | 1000 | 1000 | 1000 | 1100 | 1100 | 1100 | 1000 | 1000 | 1000 | 1100 | 1200 |
| 30 | 1100 | 1000 | 1100 | 1100 | 1000 | - | - | - | - | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1200 | 1200 | 1100 | 1200 | 1200 | 1100 | 1400 | 1300 |
| 31 | 1100 | 1200 | 1200 | 1000 | 1000 | 1100 | D | O | W | N | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1200 | 1200 | 1200 | 1100 | 1200 | 1200 | 1200 | 1100 |

FIGURE 8. INPUT DATA: $SO_2$ CONCENTRATIONS IN STACK



Jan 1976 RAPS REPORT

Power Station

| Day | Ref. Gas (mcf/d) | Hydrogen Gas (mcf/d) | Fuel Oil (mgal/d) | API | Slop Oil (mgal/d) | API | Total Steam Output (10³#/d) |
|---|---|---|---|---|---|---|---|
| 1/1 | 4388 | 2993 | 78 | 6.4 | 32 | 31.8 | 17135 |
| 2 | 4650 | 2250 | 75 | 6.4 | 20 | 31.8 | 17122 |
| 3 | 4061 | 1509 | 90 | 6.4 | 19 | 30.0 | 17444 |
| 4 | 4186 | 1537 | 98 | 6.6 | 17 | 30.1 | 17597 |
| 5 | 4667 | 2298 | 95.0 | 6.6 | 19 | 6.3 | 17919 |
| 6 | 5247 | 2373 | 107 | 5.5 | 3 | 6.3 | 17309 |
| 7 | 4595 | 2065 | 98 | 5.5 | 19 | 33.9 | 17218 |
| 8 | 4920 | 1950 | 91 | 15.0 | 18 | 25.0 | 17908 |
| 9 | 5970 | 2290 | 78 | 15.0 | 21 | 33.9 | 17410 |
| 10 | 5654 | 2596 | 79 | 1.0 | 28 | 34.5 | 17380 |
| 11 | 6645 | 2913 | 70 | 1.0 | 21 | 34.1 | 16968 |
| 12 | 6578 | 2756 | 67 | 10.9 | 19 | 33.9 | 16254 |
| 13 | 7290 | 1970 | 63 | 10.9 | 19 | 25.3 | 15815 |
| 14 | 7256 | 2328 | 62 | 22.5 | 18 | 15.0 | 16709 |
| 15 | 7455 | 2508 | 62 | 22.5 | 28 | 15.0 | 18177 |
| 16 | 7250 | 2484 | 72 | 22.5 | 17 | 9.1 | 16509 |
| 17 | 7250 | 2522 | 84 | 6.0 | 22 | 9.1 | 17105 |
| 18 | 7250 | 2439 | 74 | 6.0 | 13 | 40.4 | 15552 |
| 19 | 7300 | 2862 | 64 | 7.5 | 19 | 39.1 | 15856 |
| 20 | 7669 | 3238 | 58 | 7.5 | 11 | 39.1 | 16055 |
| 21 | 6866 | 3182 | 60 | 17.1 | 21 | 39.1 | 16029 |
| 22 | 7132 | 3921 | 63 | 17.1 | 20 | 39.1 | 15709 |
| 23 | 7710 | 4100 | 49 | 16.8 | 20 | 38.2 | 15171 |
| 24 | 6637 | 3919 | 59 | 16.8 | 18 | 38.2 | 15156 |
| 25 | 6032 | 3487 | 64 | 16.8 | 22 | 38.2 | 15450 |
| 26 | 5421 | 3635 | 73 | 16.5 | 14 | 34.9 | 15986 |
| 27 | 5222 | 3701 | 46 | 16.5 | 13 | 34.9 | 15717 |
| 28 | 5528 | 4254 | 64 | 21.3 | 13 | 34.9 | 16342 |
| 29 | 5487 | 4249 | 68 | 21.3 | 16 | 34.9 | 17934 |
| 30 | 5234 | 4229 | 60 | 21.4 | 22 | 34.9 | 16222 |
| 31 | 4928 | 3318 | 69 | 6.1 | 22 | 28.7 | 13677 |
|  |  | 89885<br>3006.5 |  |  | 19.5 |  |  |

FIGURE 9. INPUT DATA: DAILY LOG

information on fuel usage, incineration, paint and solvent usage, and production was obtained from the companies. Emissions of each of the five criteria pollutants were calculated using the 1975 data along with AP-42 emission factors. Also, each of the companies was assigned to a grid square after determination and verification of its UTM coordinates.

In three cases where data was unobtainable due to lack of cooperation of the companies involved, Illinois EPA Emission Inventory (IEI), or Missouri Emission Inventory (MEI) data from 1973 were used to calculate emission. Those cases are identified by an asterisk in Table 17, which lists all companies included in the inventory, its grid square location and total pounds of emissions of each of the five criteria pollutants. As a starting point for the inventory, IEI and MEI were consulted, using the numerical criteria shown in Table 18 for placing a source in the industrial area category.

TABLE 18. EMISSION LIMITS FOR INDUSTRIAL AREA SOURCES

| PARTICULATES | $SO_X$ | $NO_X$ | HC | CO |
|---|---|---|---|---|
| $1 < X < 25$ | $1 < X < 100$ | $1 < X < 30$ | $1 < X < 10$ | $1 < X < 10$ |

X = Tons/Year of Pollutant Emitted

Upper limits in Table 18 are based on emissions of less than 0.01% of a given pollutant. Included in the tabulation were all companies whose emissions fell within these limits, as well as those for which no data or apparent questionable data appeared in the above inventories. All companies were contacted and up-to-date information was obtained and recorded.

The Industrial Area Source Inventory is an annual inventory. Since the total, cumulative contributions of this category are less than 0.3% for any pollutant, hourly values are determined by dividing the annual values by 8760. The resulting errors are not significant.

Data listed in Table 17 were entered on coding sheets, keypunched on cards and entered into the RAPS Emission Inventory System at Research Triangle Park, North Carolina.

TABLE 17. ANNUAL EMISSIONS FROM INDUSTRIAL AREA SOURCES

| COMPANY NAME | GRID SQUARE | EMISSIONS (LBS) PART | $SO_X$ | $NO_X$ | HC | CO |
|---|---|---|---|---|---|---|
| A. B. Chance Transformer Works Washington, Mo. | #39 | 111 | 110 | 742 | 107,446 | 98 |
| Beall Tool Mfg. Div. of Varien Corporation East Alton, Ill. | #1240 | 1,356 | 4,192 | 12,421 | 502 | 2,099 |
| Coates Steel Prod. Granville, Ill. | #1795 | 11,730 | 42,182 | 51,720 | 2,406 | 3,988 |
| Continental Can Plant* 2419 Lemp St. Louis, Mo. | #958 | 0 | 0 | 0 | 6,000 | 0 |
| Corn Sweetners Granite City, Ill. | #1128 | 417 | 25 | 9,591 | 125 | 709 |
| Drug Package, Inc. O'Fallon, Mo. | #2034 | 540 | 32 | 28,170 | 162 | 918 |
| East St. Louis Castings Co. East St. Louis, Illinois | #1252 | 2,023 | 0 | 0 | 0 | 1,725 |
| Eaton Corp. Washington, Mo. | #2011 | 1,910 | 0 | 0 | 0 | 0 |
| Excelsior Foundry Belleville, Ill. | #1561 | 410 | 1,562 | 1,650 | 83 | 110 |
| Gilster-Mary Lee Chester, Ill. | #1579 | 48 | 3 | 576 | 14 | 82 |
| G & S Foundry Freeburg, Ill. | #1584 | 509 | 454 | 480 | 24 | 136 |
| Havin Material Service St. Clair, Mo. | #2022 | 2,702 | 0 | 0 | 0 | 0 |

(continued)

TABLE 17 (continued)

| COMPANY NAME | GRID SQUARE | EMISSIONS (LBS) | | | | |
|---|---|---|---|---|---|---|
| | | PART | $SO_X$ | $NO_X$ | HC | CO |
| Havin Material Service<br>Sullivan, Mo. | #2002 | 2,366 | 0 | 0 | 0 | 0 |
| International Shoe Company*<br>St. Clair, Mo. | #2022 | 465 | 1,761 | 1,920 | 93 | 124 |
| J. C. George<br>St. Clair, Mo. | #56 | 0 | 0 | 0 | 0 | 0 |
| Jennison-Wright Corporation<br>Granite City, Ill. | #1128 | 7,576 | 3,956 | 8,844 | 6,792 | 9,102 |
| Kellwood Co. Finishing Div.<br>New Haven, Mo. | #3 | 180 | 108 | 2,160 | 54 | 306 |
| Kohen Concrete Products<br>Germantown, Ill. | #1768 | 1,506 | 0 | 0 | 0 | 0 |
| Kurtz Concrete<br>St. Charles, Mo. | #2126 | 11,000 | 0 | 0 | 0 | 0 |
| Maclay Concrete<br>Festus, Mo. | #467 | 7,200 | 0 | 0 | 0 | 0 |
| Mascoutah Grain and Feed<br>Mascoutah, Ill. | #1637 | 13,702 | 0 | 0 | 0 | 0 |
| Masters Bros. Sand Co.<br>Pevely, Mo. | #292 | 4,000 | 0 | 0 | 0 | 0 |
| Micro Alloy Corporation<br>O'Fallon, Mo. | #2034 | 167 | 10 | 2,004 | 50 | 284 |
| Missouri Meerschaum<br>Washington, Mo. | #47 | 262 | 2,685 | 34 | 23,876 | 46 |

(continued)

TABLE 17 (continued)

| COMPANY NAME | GRID SQUARE | EMISSIONS (LBS) | | | | |
|---|---|---|---|---|---|---|
| | | PART | $SO_X$ | $NO_X$ | HC | CO |
| Missouri Portland Loading Terminal St. Louis, Mo. | #972 | 1,800 | 0 | 0 | 0 | 0 |
| Mon Clair Grain St. Clair County Belleville, Ill. | #1484 | 16,977 | 0 | 0 | 0 | 0 |
| Mon Clair Grain Waterloo, Ill. | #1146 | 15,400 | 0 | 0 | 0 | 0 |
| National Mine Service Nashville, Ill. | #1829 | 0 | 0 | 1,500 | 750 | 2,500 |
| New Baden Grain Company New Baden, Ill. | #1714 | 6,616 | 0 | 0 | 0 | 0 |
| Peavy Flour Mills Alton, Ill. | #1020 | 12,750 | 0 | 0 | 0 | 0 |
| Permaneer Corp. Union, Mo. | #2015 | 600 | 593 | 4,011 | 15,100 | 531 |
| Pre-Coat Metals St. Louis, Mo. | #852 | 3,400 | 204 | 40,800 | 16,700 | 5,780 |
| Koesch Enamel Mfg. Belleville, Ill. | #1511 | 1,780 | 107 | 40,940 | 534 | 3,026 |
| Ruprecht Quarry Lemay, Mo. | #744 | 48,000 | 0 | 0 | 0 | 0 |
| St. Louis Grain Corporation Duncan Street St. Louis, Mo. | #858 | 179 | 0 | 0 | 0 | 0 |
| Washington Metal Products Washington, Mo. | #59 | 1,080 | 4,090 | 4,320 | 216 | 288 |

(continued)

TABLE 17 (continued)

| COMPANY NAME | GRID SQUARE | EMISSIONS (LBS) | | | | |
|---|---|---|---|---|---|---|
| | | PART | $SO_X$ | $NO_X$ | HC | CO |
| St. Louis Grain Corporation<br>Foot of E. Grand<br>St. Louis, Mo. | #1008 | 1,607 | 0 | 0 | 0 | 0 |
| St. Louis Grain Corporation<br>Cahokia, Ill. | #997 | 535 | 0 | 0 | 0 | 0 |
| St. Louis Steel Casting<br>St. Louis, Mo. | #849 | 13,520 | 0 | 2,080 | 0 | 0 |
| Spartan Aluminum Products<br>Sparta, Ill. | #2448 | 6,840 | 0 | 0 | 0 | 0 |
| Sterling Steel Casting Co.<br>Sauget, Ill. | #1095 | 1,414 | 988 | 5,460 | 162 | 697 |
| Sunoco Petroleum<br>255 E. Monroe<br>Kirkwood, Mo. | #404 | 0 | 0 | 0 | 4,105 | 0 |
| Sunoco Petroleum<br>1252 E. Road<br>Manchester, Mo. | #789 | 0 | 0 | 0 | 728 | 0 |
| Thompson Asphalt<br>Alton, Ill. | #2281 | 7,025 | 4 | 870 | 22 | 123 |
| Trautman Quarry<br>Pevely, Mo. | #355 | 13,336 | 0 | 0 | 0 | 0 |
| Troy Grain Co.<br>Troy, Ill. | #1624 | 4,300 | 0 | 0 | 0 | 0 |
| Vitro Products*<br>St. Louis, Mo. | #1072 | 0 | 0 | 0 | 22,400 | 0 |
| Weber, Inc., Fred<br>O'Fallon Plant<br>O'Fallon, Mo. | #118 | 3,250 | 5,680 | 6,000 | 300 | 400 |

(continued)

TABLE 17 (continued)

| COMPANY NAME | GRID SQUARE | EMISSIONS (LBS) | | | | |
|---|---|---|---|---|---|---|
| | | PART | $SO_X$ | $NO_X$ | HC | CO |
| Weber, Inc., Fred<br>Festus Asphalt Plant<br>Festus, Mo. | #467 | 3,590 | 6,305 | 6,660 | 333 | 444 |
| Weber, Inc., Fred<br>South Asphalt Plant<br>Lemay, Mo. | #2245 | 13,230 | 41,350 | 43,680 | 2,184 | 2,972 |
| Weber, Inc., Fred<br>North Asphalt Plant<br>Creve Coeur, Mo. | #2147 | 16,565 | 93 | 18,600 | 465 | 2,635 |
| Western Litho Plate<br>St. Louis, Mo. | #281 | 240 | 14 | 2,880 | 72 | 96 |
| Wirco Castings, Inc.<br>New Athens, Ill. | #1683 | 1,050 | 0 | 0 | 0 | 0 |
| TOTALS - lbs. | | 265,264 | 116,508 | 298,113 | 211,698 | 39,219 |
| - Tons | | 133 | 58 | 149 | 106 | 20 |

* ASTERISK INDICATES DATA DERIVED FROM STATE AGENCY INVENTORIES

## 1.3 EMISSION FACTOR VERIFICATION STUDIES

### 1.3.1 Background

Emission estimates are based on consumption or production figures from which emissions are calculated using an emission factor. Emission factors are averaged numbers relating emissions to consumption or process data. In some cases, the relationship is direct and relatively uncomplicated. For example, for every ton of bituminous coal burned, a total of 38S pounds of sulfur dioxide is produced, where S indicates the sulfur content of the fuel, on a weight percent basis. Thus, if a plant burns 100 tons of 3% sulfur coal per hour, it emits

$$100 \times 38 \times 3 = 11{,}400$$

11,400 lbs of $SO_2$ per hour. Since in this particular case the sulfur is contained in the fuel and is converted virtually completely (95%) to $SO_2$, the numbers resulting from the use of the emission factor are quite accurate and reliable.

If, on the other hand, we wish to determine the amount of oxides of nitrogen produced by the same operation, a somewhat different situation ensues. The emission factor for a boiler burning bituminous coal, as given in the EPA publication AP-42 "Compilation of Air Pollution Emission Factors", varies with both boiler type and size, from 6 to 55 lbs. of $NO_X$ per ton of coal. This is because the factors affecting $NO_X$ production include flame and furnace temperature, residence time of the combustion gases, rate of cooling, amount of excess air, as well as the amount of nitrogenous compounds in the fuel. Thus, the emission factor of 18, which is applicable to a pulverized coal boiler of this size, is an averaged value. Actual values may depart significantly from the numbers obtained by such a factor.

In order to improve the accuracy of the emission inventory gathered at

St. Louis, a number of representative sources were sampled and their stack effluents analyzed. An attempt was made to encompass a wide variety of the larger point sources: large and medium sized power plants burning coal, fuel oil and gas; industrial boilers of different types and sizes; and industrial operations, such as catalyst recovery units in a petroleum refinery, and cement kilns, known or suspected of being major sources of pollution.

The following sources were sampled in 1975 and 1976:

Illinois Power's Wood River Power Plant, Wood River, Illinois
    Boiler No. 1, operated on gas
    Boiler No. 1, operated on fuel oil
    Boiler No. 4, operated on coal

Highland Power Plant, Highland, Illinois
    Boiler No. 3, operated on coal

Stag Brewery, Belleville, Illinois
    Boiler No. 1, operated on coal

General Motors Assembly Plant, St. Louis, Missouri
    Boiler No. 2, operated on coal

Amoco Refinery, Hartford, Illinois
    Boiler No. 6, operated on oil and gas
    Catalyst Regeneration Unit

Chrysler Motors Assembly Plant, Fenton, Missouri
    Boiler No. 1, operated on gas

Owens - Illinois Glass Company, Alton, Illinois
    "A" Glass Furnace, operated on gas

Alpha Portland Cement Company, Affton, Missouri
    Cement Kiln, wet process, coal-fired

U.S.S. Agri-Chem, Crystal City, Missouri
    Nitric Acid Production Unit

General Motors Assembly Plant (Re-test), St. Louis, Missouri
    Boiler No. 2, operated on coal

In Appendix B is a list of Plant and Point ID's and SCC codes for which source test emission factors are being used in the RAPS inventory.

### 1.3.2 Test Methods

In general, the test methods specified in the Appendix of Part 60, CFR Title 40, "Standards of Performance for New Stationary Sources" were used. The methods include:

Method 1 - Sample and Velocity Traverses
2 - Determination of Stack Gas Velocity
3 - Gas Analysis of $CO_2$, Excess Air and Dry Molecular Weight
4 - Determination of Moisture in Stack Gases
5 - Determination of Particulate Emissions
6 - Determination of $SO_2$ Emissions
7 - Determination of Nitrogen Oxide Emissions
8 - Determination of Sulfuric Acid Mist Emissions

### 1.3.3 Results and Discussion

Serious problems were encountered with stack gas velocity measurements using Method 2. Using mass balance methods as a check, it became apparent that the values obtained with an S-type Pitot tube, used in accordance with Method 2, were high by amounts ranging from 8 to 78 percent. Reproducibility was adequate, and repeated calibration of the Pitot tube indicated that correct readings were obtained. A careful check of the literature indicated that high readings had been observed by other investigators. Burton (7) indicated that values of 104 to 150% of the rated value can be obtained. Grove (8) presented data indicating that, (a) significant errors are always positive, and (b) they can be very large. The most common source of errors is due to cyclonic flow, unfortunately a fairly common occurrence in power plant stacks, where "double entry" stacks (two boilers feeding one stack) are frequently used.

A comparison of measured and calculated flows is shown in Table 19. The flow rate was calculated from known fuel consumption, fuel composition and excess air data.

TABLE 19. COMPARISON OF MEASURED* AND CALCULATED** FLOWS

| Location | Flow, SCFH Measured | Flow, SCFH Calculated | % Δ |
|---|---|---|---|
| Wood River #1 | 10,086.750 | 8,237,263 | +22.5 |
| Wood River #4 | 17,981,280 | 13,089.200 | +37.4 |
| Highland Power | 1,386,070 | 910,920 | +52.2 |
| Stag Brewery | 1,394,990 | 782,900 | +78.2 |
| Monsanto | 1,687,655 | 1,563,000 | + 8.0 |
| General Motors | 1,598.005 | 1,434,847 | +11.4 |

* Using S-type Pitot tube, EPA Method 2

** Based on stoichiometry and excess air

One way of ascertaining the correctness of the data is by comparing the mass flow $SO_2$ calculated from fuel consumption and sulfur analysis of the fuel, on one hand, with the value obtained from stack gas flow and analysis, on the other. The former is calculated according to Equation 1

$$W_{SO_2} = W_c \times 38 \times S \quad , \qquad (1)$$

where

$W_{SO_2}$ - weight of $SO_2$ produced, lbs/hr

$W_c$ - weight of coal consumed, tons/hr

$S$ - % sulfur in coal, dry basis

This value should be equal to one obtained from Equation 2

$$W_{SO_2} = C_{SO_2} \times Q_S \quad , \qquad (2)$$

where

$C_{SO_2}$ - Concentration of $SO_2$ in stack gas, lbs/SCF

$Q_S$ - Stack gas flow rate, SCF/hr

For example, the flow rate for Boiler #4 at Wood River was calculated thusly:

Assumed combustion reactions:

(1) $C + O_2 \rightarrow CO_2$
(2) $2\ H_2 + O_2 \rightarrow 2\ H_2O$ (Excluded from calculation for dry flue gas)
(3) $S + O_2 \rightarrow SO_2$
(4) Oxidation reaction uncertain

| Composition of Coal | | Lb-mols/100 lbs Coal | Combustion Reaction | Oxygen Required for Combustion, mols |
|---|---|---|---|---|
| C | 61.43% | 5.12 | (1) | 5.12 |
| $H_2$ | 4.38% | (2.19) | (2) | (1.09) |
| S | 3.21% | 0.10 | (3) | 0.10 |
| $O_2$ | 9.67% | 0.30 | | -.30 |
| $N_2$ | 1.11% | 0.04 | (4) | - |
| $H_2O$ (moisture) | 11.82% | (0.66) | (2) | - |
| Ash | 8.55% | | | |
| Chlorides | 0.02% | | | |
| | 100.19% | | | 6.01 mols oxygen |

Average Excess Air: 40% 2.40

Total 8.41

Corresponding Nitrogen @ 3.76 x $O_2$ 31.77

Dry flue gases per 100 lbs. coal, lb-mols:

$CO_2 + SO_2 + O_2 + N_2$ + Air Nitrogen

5.12 + 0.10 + 2.40 + 0.04 + 31.77 = 39.43 lb-mols/100# coal

$$\text{lb-mols} \times 386\ \frac{\text{SCF}}{\text{lb-mol}} = \text{SCF}$$

39.43 x 386 = 15,220 SCF/100# coal

@ 43 tons coal/hr. = 13,089,200 SCFH

A comparison of results is shown in Table 20. As can be seen from Table 20, the values obtained using flow rates based on mass balance show a much better agreement with values obtained from emission factors, than those based on Pitot measurements.

TABLE 20. COMPARISON OF $SO_2$ EMISSIONS BASED ON CALCULATED AND MEASURED FLOW RATES

| Location | $W_{SO_2}$ - Weight of $SO_2$ Produced, Based on | | |
|---|---|---|---|
| | AP-42 Emission Factor | Calculated Flow | Measured Flow |
| Wood River #1 (oil) | 153 lbs/hr | 178 lbs/hr | 217 lbs/hr |
| Wood River #4 | 5245 | 5104 | 7035 |
| Highland Power | 414 | 433 | 658 |
| Stag Brewery | 75 | 82 | 125 |
| General Motors | 479 | 472 | 546 |

For this reason, calculated flow rates were used whenever there was an indication of non-linear flow in the stack, as indicated by the fact that turning the Pitot tube 90° on axis did not give a zero reading on the manometer.

Using the most reliable available results, experimental emission factors were calculated for $SO_2$, $NO_X$, CO, HC, and particulates for the sources tested. These emission factors are compared in Table 21 with the standard emission factors from AP-42.

Even though relatively few source tests have been run, certain conclusions can be drawn from the results obtained:

1. Determinations of stack gas volumes according to EPA Method 2 is uncertain. Incorrect results are obtained in a high number of cases, since the basic assumption of laminar flow, parallel to the walls of the stack, frequently does not occur.
2. Engineering calculations of mass flow, based on ultimate analysis of the fuel and determinations of the excess air in the stack gases, give reasonably accurate results. This is confirmed through sulfur balance calculations. For example, the average experimental

## TABLE 21. COMPARISON OF AP-42 AND EXPERIMENTAL EMISSION FACTORS

| | | AP-42 EMISSION FACTORS | | | | | EXPERIMENTAL EMISSION FACTORS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SCC CODE(1) | $SO_2$ | $NO_x$ | PART | CO | HC | $SO_2$ | $NO_x$ | PART | CO | HC |
| Chrysler Motors - #1 (4) | 10200601 | - | 230 | - | - | - | - | 235.5 | - | - | - |
| Owens Ill.-"A" Glass Furnace(5) | 30501401 | - | - | 2.00 | - | - | 2.2 | 552 | 0.58 | - | - |
| Alpha Cement - Wet Process (6) | 30500705 | 23.8 | 2.6 | 228 | - | - | 28.4 | 7.9 | 203 | - | - |
| USS Agri Chem - $HNO_3$ Unit (7) | 30101301 | - | 52.5 | - | - | - | - | 60.4 | - | - | - |
| Wood River #1 (4) | 10100601 | - | 600 | 10 | 17 | 1 | - | 105 | - | 2.8 | - |
| Wood River #1 (8) | 10100501 | 144S(2) | 105 | 8 | 3 | 2 | 168S | 16 | 1.0 | 0.4 | 0.17 |
| Wood River #4 (9) | 10100202 | 38S | 18 | 17A(3) | 1 | 0.3 | 37S | 1.4 | 10.0A | - | 0.02 |
| Highland Power (9) | 10100208 | 38S | 15 | 5A | 2 | 1 | 40S | 4.1 | 0.4A | - | - |
| Stag Brewery (9) | 10200208 | 38S | 15 | 5A | 2 | 1 | 46S | 7.2 | 1.9A | 0.3 | 0.14 |
| General Motors - #2 (9) | 10200209 | 38S | 15 | 13A | 2 | 1 | 37S | 10.8 | 23.6A | 0.7 | 0.03 |
| Amoco Cat Cracker Recovery (10) | 30600201 | 439 | 71 | 242 | - | 220 | 246 | 153 | 360 | - | 0.48 |

(1) - The Source Classification Code and associated emission factors can be found in Appendix C of AP-42
(2) - S is the percentage sulfur in fuel
(3) - A is the percentage ash in fuel; emissions before control equipment
(4) - gas fired - lbs. per $10^6$ cu. ft.
(5) - gas fired - lbs. per ton glass produced
(6) - coal fired - lbs. per ton cement produced
(7) - lbs. per ton 100% acid produced
(8) - oil fired - lbs. per $10^3$ gal.
(9) - coal fired - lbs. per ton of coal
(10) - lbs. per $10^3$ bbl fresh feed

emissions factors for $SO_2$ for coal burning installations come out to 38.75S compared with 38S suggested in AP-42.

3. The emission factors in Table 21 are applicable only to the specific installations for which they were obtained. However, definite patterns appear to exist, which seem to have more general validity:

   a) Emission facotrs of $NO_X$ for large combustion sources (utilities) appear to be too high by a variable, but substantial, margin. The experimentally obtained factors range from a low of 7.7% to 72% of the applicable AP-42 factors. For smaller sources good agreements were obtained.

   b) Experimental emission factors for particulates similarly vary from 8 to 58% of the applicable AP-42 factors for installations which do not have precipitators. In the presence of the latter, their assumed efficiency becomes the determining factor.

   c) Hydrocarbon and CO emissions, which are rather insignificant for combustion sources, have also been found to be less than those suggested by the AP-42 factors.

### 1.3.4 Sulfuric Acid Mist

An alternate method was used for determining sulfuric acid mist. The current standard method for $SO_3$ in stack gases is EPA Method 8 (CFR 40, 60.85, Appendix-Test Methods). In this method, the sample of stack gases is drawn through a series of impingers. The first impinger contains 100 ml of 80% iso-propanol; the second and third 100 ml of 3% hydrogen perioxide. There is a filter between the first and second impinger to retain entrained particulates. The contents of the impingers are analyzed for sulfate using the barium perchlorate-thorin method.

Recent work cast doubts on both accuracy and reproducibility of Method 8. The method assumes that only $SO_3$ (sulfuric acid mist) will be retained in the first impinger and filter (both of which are analyzed together). However, Hillenbrand (9) found that substantial amounts of $SO_2$ are retained in the first impinger, some of which is subsequently oxidized to $SO_3$, thus contributing to high results. For this reason a different technique was used, which was first described by Goksøyr and Ross (10) and subsequently verified by Lisle and Sensenbaugh (11). This method is generally referred to as the Shell method, as it was developed in their laboratories. The method is based on the condensation of sulfuric acid mist at temperatures below its dew point (but above the dew point of the water) in a condenser backed up by a fritted glass filter (Figure 10). The condensate is washed out and titrated.

Data presented in references 10 and 11 indicate that adsorption of $SO_3$ is essentially complete, repeatability is excellent, $SO_2$ in concentrations up to 2000 ppm does not interfere, and a precision of ± 0.3 ppm of $SO_3$ can be readily attained.

The method was then evaluated in our laboratories. The results of the evaluation indicate an average 100.1 ± 6.5% recovery with no significant interference from any of the variables tested (12).

The gas sampling train consists of water-cooled coil condenser maintained below the dew point of sulfuric acid at 140°-194°F, followed by a fritted glass plate and chilled impingers containing an isopropanol and hydrogen peroxide mixture, followed by an impinger containing silica gel for drying. This setup is shown in Figure 11.

The condensed sulfuric acid mist in the coil condenser is water washed from the condenser. The final determination is made by titrating the solution with barium chloride, using a thorin indicator. Isopropanol is added to the solution to improve the rapidity with which the barium sulfate precipitates during titration.

Sulfur dioxide in the gas sample is oxidized to sulfur trioxide in the impingers containing the hydrogen peroxide. Sulfur dioxide is then determined by titrating the hydrogen perioxide solution with barium chloride, using a thorin indicator.

The $SO_3$ concentrations of large and small boilers were investigated first. The concentrations ranged from 2.7 to 44.3 ppm, well within the range indicated by other investigators. As indicated in Figure 12, there appears

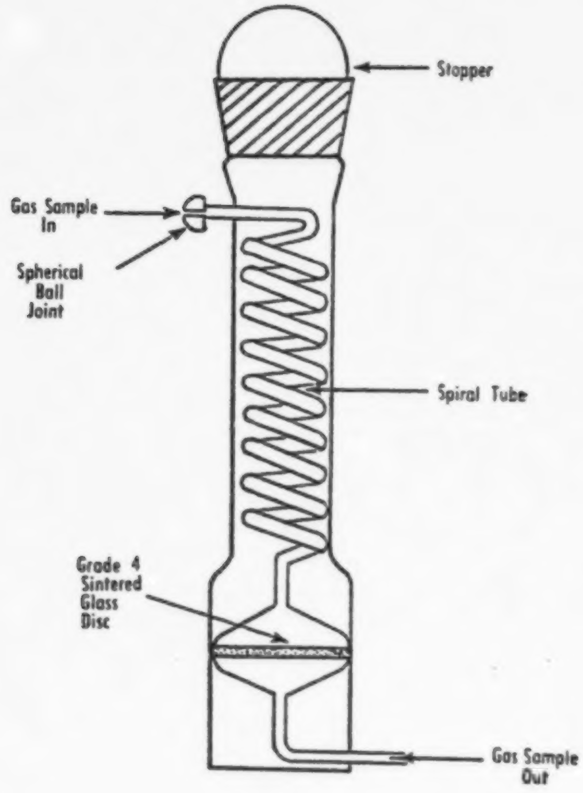

Stopper
Gas Sample In
Spherical Ball Joint
Spiral Tube
Grade 4 Sintered Glass Disc
Gas Sample Out

FIGURE 10. SULFUR TRIOXIDE COLLECTOR

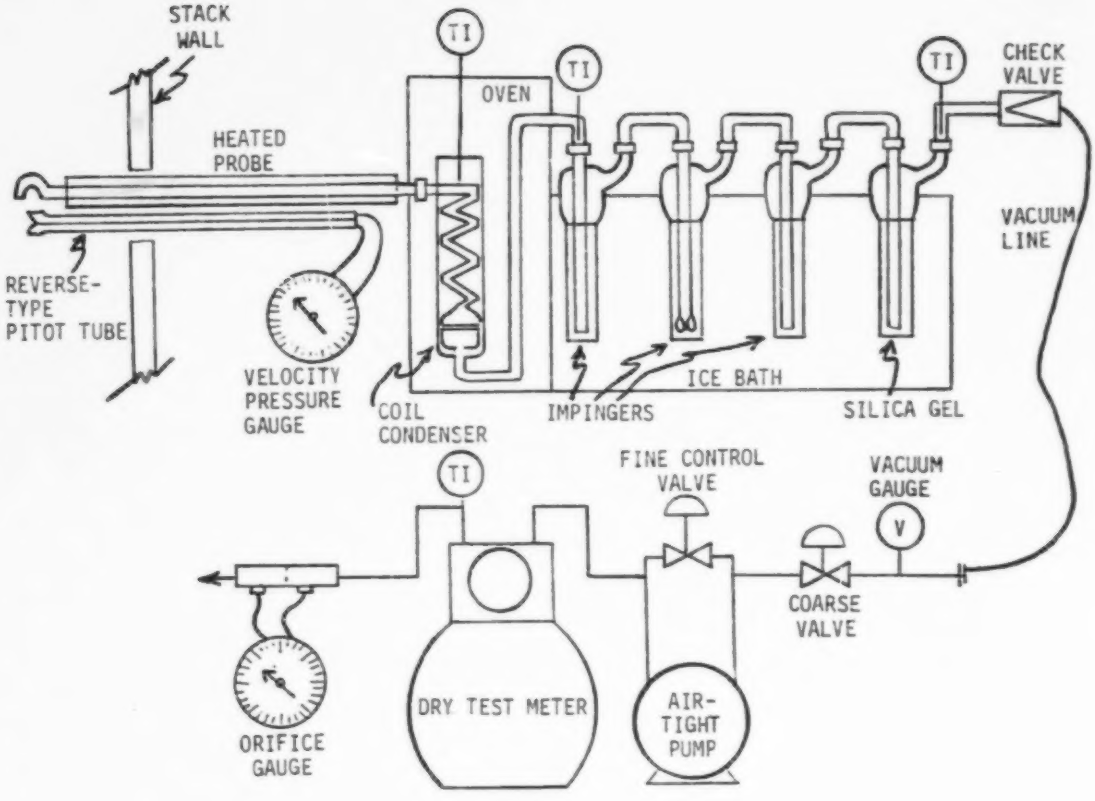

STACK WALL
TI
OVEN
TI
TI
CHECK VALVE
HEATED PROBE
VACUUM LINE
REVERSE-TYPE PITOT TUBE
VELOCITY PRESSURE GAUGE
COIL CONDENSER
ICE BATH
IMPINGERS
SILICA GEL
TI
FINE CONTROL VALVE
VACUUM GAUGE
V
COARSE VALVE
DRY TEST METER
AIR-TIGHT PUMP
ORIFICE GAUGE

FIGURE 11. SULFURIC ACID MIST SAMPLING TRAIN

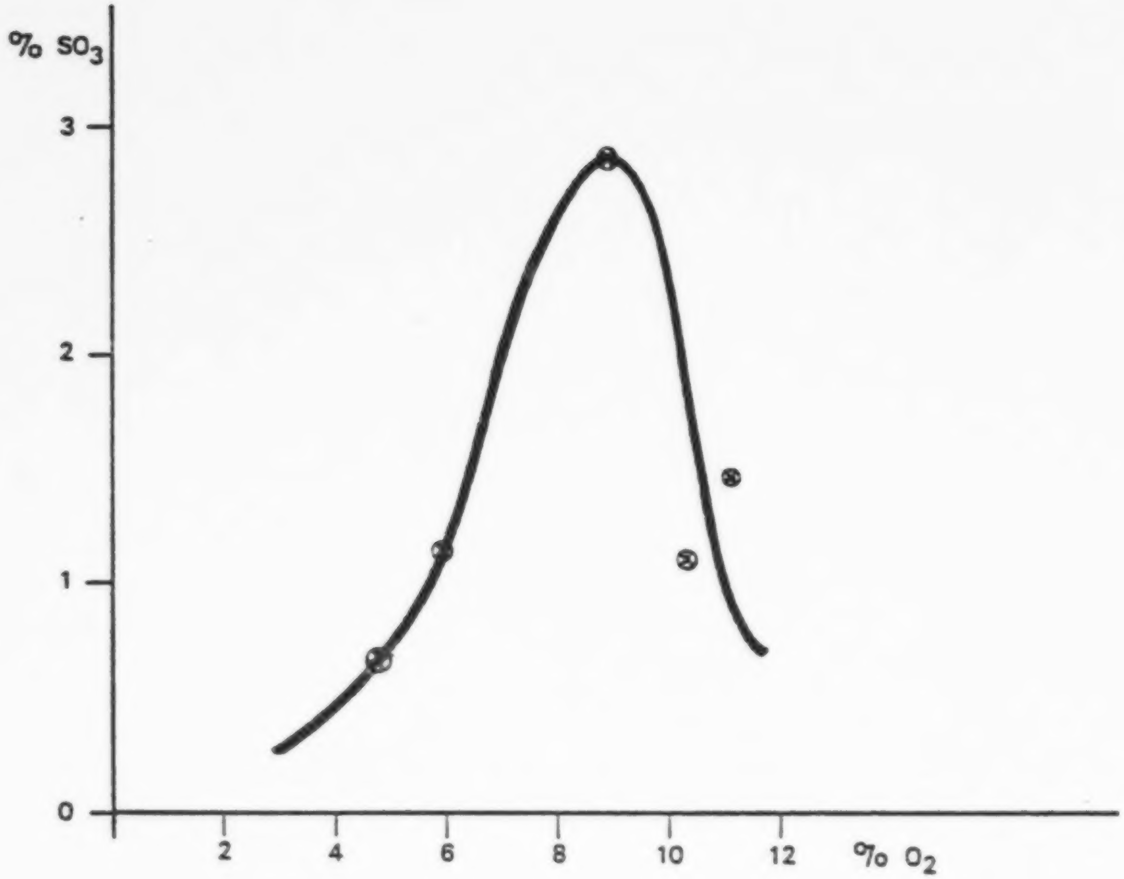


FIGURE 12. PERCENTAGE CONVERSION OF $SO_2$ TO $SO_3$ IN UTILITY BOILERS

to be a marked dependence on excess oxygen. The percentage of $SO_3$ increased with increasing oxygen up to about 9%, then dropped rapidly. This may be due to the cooling effect of large amounts of excess air. There did not seem to be any correlation with the sulfur content of the fuel nor did there appear to be any marked effect of boiler capacity on the amount of concentration of $SO_3$ produced. Data are presented in Table 22.

The RMS average $SO_3$ emission appears to be about 1.85% of the $SO_2$ emission. This factor will be incorporated in the data handling system output program, which will report $SO_3$ emissions based on the corresponding $SO_2$ emissions. Using the current figures for $SO_2$, this amounts to an annual emission of 22,585 tons of $SO_3$ per year for the St. Louis AQCR.

### 1.3.5 Particle Size Distribution

Particle size testing was performed with an Andersen Stack Sampling head coupled with the apparatus used for the standard EPA method for particulates. The Andersen is a fractionating inertial impactor which separates particles according to aerodynamic characteristics.

The Mark II sampling head consists of a stainless housing plate holder and nine jet plates. The plates have a pattern of precision-drilled orifices. The nine plates, separated by 2.5 millimeter stainless steel spacers, divide the sample into eight fractions or particle size ranges. The jets on each plate are arranged in concentric circles which are offset on each succeeding plate. The size of the orifices is the same on a given plate, but is smaller for each succeeding downstream plate. Therefore, as the sample is drawn through the sampler at a constant flow rate, the jets of air flowing through any particular plate direct the particulates toward the collection area on the downstream plate directly below the circles of jets on the plate above. Since the jet diameters decrease from plate to plate, the velocities increase such that whenever the velocity imparted to a particle is sufficiently great, its inertia will overcome the aerodynamic drag of the turning airstream and the particle will be impacted on the collection surface.

The Mark III is identical to the Mark II except the location of the orifices in the plates have been modified to permit the use of a special collection substrate (glass fiber in our tests). This permits lighter tare

## TABLE 22. SULFUR OXIDE ANALYSES AND RATIOS

| | $SO_2$ | | $SO_3$ | | $SO_3/SO_2$ | | Excess $O_2$ | Boiler Cap. lbs steam/hr | % Sulfur in Fuel |
|---|---|---|---|---|---|---|---|---|---|
| | $\frac{\text{lbs}}{10^6\ \text{SCF}}$ | ppm | $\frac{\text{lbs}}{10^6\ \text{SCF}}$ | ppm | Wt. | Vol. | | | |
| Wood River #1 | 21.5 | 120.5 | .6 | 2.7 | 2.82% | 1.49% | 8.9% | 450,000 | .29 |
| #4 | 389.5 | 2183.5 | 3.4 | 15.4 | 1.13 | .70 | 6.0 | 710,700 | 3.21 |
| Highland | 475.0 | 2662.8 | 3.2 | 14.7 | .69 | .55 | 4.8 | 60,000 | 3.25 |
| Stag | 119.0 | 667.1 | 1.6 | 7.5 | 1.41 | 1.12 | 11.2 | 50,000 | 3.25 |
| GM | 349.0 | 1956.5 | 9.8 | 44.3 | 2.83 | 2.26 | 8.9 | 80,000 | 3.46 |
| Amoco | 126.0 | 706.3 | 1.4 | 6.4 | 1.13 | .91 | 10.5 | 200,000 | *3.00 |
| Average | 246.0 | 1382.8 | 3.3 | 15.2 | 1.69 | 1.17 | 8.4 | | |
| RMS Average | | | | | 1.86 | | | | |

*Weighted average

weights for gravimetric analyses and a collection of material for chemical analysis. Figure 13 illustrates the Andersen sampling head and an exploded view of the plate holder and plates.

At one location fourteen tests were performed to evaluate variations of testing methods consisting of placing the Andersen in-stack, out of stack (in oven), using Mark II plates and Mark III plates with filters. The main objective of these tests was to arrive at a testing arrangement to be used on all subsequent tests. However, there was no clearcut single method which proved better than the other. Each of these methods has its advantages which may make it desirable for any one individual test.

Sampling in the stack avoids any problems with extracting a sample and having some of it deposited in the probe. Also, the sample head is at the same temperature as the stack gases which avoids any problems of condensation. In-stack sampling, however, means the impaction surface is vertical and is subject to having the sample dislodged in handling. When sampling must be done vertically in a duct, from the top down, this method cannot be used.

Sampling with the Andersen sampler in the sample oven at the end of a heated probe affords much better handling. The sample head can be kept vertically with the plates horizontal at all times. The sample head can be clamped in place and not threaded on to the probe, thus minimizing handling.

Isokinetic sampling rates can be determined more readily when the Andersen sampler is in the oven since the probe in the stack has a Pitot attached. There are two problems with sampling this way: (1) the oven can be heated only to 350°F, which may not be as high as the temperature in the stack; and (2) larger particles tend to be deposited in the probe, which lowers the weight of the deposit on the first two plates.

Parallel sampling with both the Mark II plates and the Mark III plates with filters indicated that there was no significant difference in the weight of sample obtained or the size distribution between these two methods. If the Mark II model is used, the number of tests is limited by sets of plates available. With the Mark III plates and filters more runs can be performed by changing the filters between runs with the available time being the only constraint on the number of runs. More care must be taken in assembling the

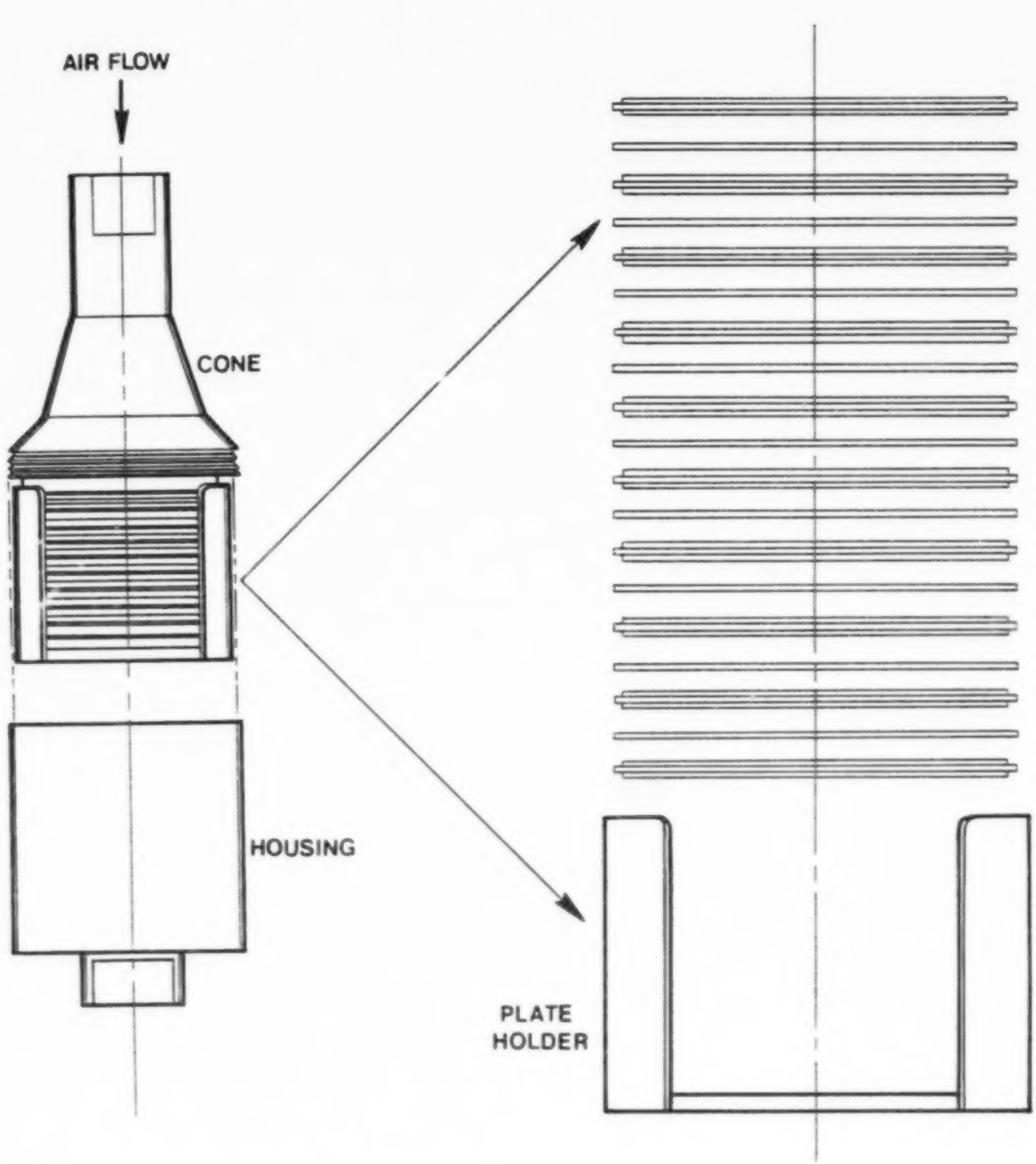

AIR FLOW
CONE
HOUSING
PLATE HOLDER

FIGURE 13. ANDERSEN STACK SAMPLER

Mark III, since the filters are pre-cut to match the plates and must be properly aligned to avoid blocking any holes.

As a result of these comparison tests, it was decided that testing would be performed with the Mark III plates and filters and that the Andersen sample head would be placed in the oven for ease in handling and subsequent analysis.*

TABLE 23. PARTICLE SIZE DISTRIBUTIONS

| Source | SCC Code | Weight % vs. Particle Size | | | | |
|---|---|---|---|---|---|---|
| | | >7μ | 3-7μ | 1-3μ | 0.5-1μ | <0.5μ |
| Ill. Power - Wood River | 1-01-002-02 | 22.5 | 22.8 | 18.5 | 8.3 | 27.9 |
| Highland Electric | 1-01-002-08 | 26.6 | 18.9 | 10.0 | 12.7 | 31.8 |
| Stag Brewery | 1-02-002-05 | 37.4 | 16.0 | 7.6 | 18.3 | 20.7 |
| General Motors | 1-02-002-09 | 14.3 | 24.4 | 18.5 | 9.2 | 33.6 |
| Amoco | 3-06-001-02 | 13.9 | 8.9 | 22.0 | 18.8 | 36.4 |
| Owens Illinois | 3-05-014-01 | 5.8 | 8.0 | 41.0 | 34.2 | 11.0 |
| Alpha Cement | 3-05-007-05 | 29.0 | 38.4 | 14.2 | 8.4 | 10.0 |

Most measurements at boiler stacks indicate a bimodal distribution, one peak at 3-7 micron and the other at less than 1 micron. The test of a glass furnace at Owens - Illinois, however, indicated a single peak at approximately 1μ.

---

*For more details, see Reference 12.

# 2.0 DATA HANDLING

The RAPS emission inventory is ultimately stored in the memory banks of a Univac 1110 computer at the National Environmental Research Center at Research Triangle Park, N.C. A "System 2000" data management system is used.

## 2.1 CODING PROCEDURES

The input and output programs were designed to be similar to the National Emission Data System (NEDS) format. In the RAPS data handling system, no actual emission data are recorded and stored (with a few exceptions). Instead, the files contain fuel consumption or process data, which are converted to mass emission by appropriate manipulation as part of the output program. The advantage of this system is its flexibility, since new or additional emissions factors can be added without disturbing the data base.

The data were received, usually once a month, in a variety of forms. An instruction sheet is made up for each source, which details the entry method (see Appendix A). A uniform coding form is then made out, which serves as a basis for the keypunchings of computer cards.

Five different types of input cards are used: Type I is used to record hourly fuel consumption process information data. Type II is for recording stack gas pollutant concentration and stack gas volumes; hourly values of concentration and flow are on alternate fields. Type III is used to record the annual data and corresponding patterns of minor sources. Type IV is used for non-criteria pollutants (annual data). Finally, Type V is used for the recording of special emission factors for non-criteria pollutants, heat emission, etc. The various coding forms are shown in Figures 14 - 17.

The following information is recorded:

Card 1

- STATE CODE
- COUNTY CODE
- PLANT ID
- PLANT NAME
- STREET ADDRESS
- ZIP CODE
- SIC
- OWNERSHIP CODE

Card 2

- STACK ID
- UTM ZONE
- UTM COORDINATES
- AREA ID
- TEMPERATURE
- STACK HEIGHT
- BOILER DESIGN CAPACITY
- STACK DIAMETER
- FLOW RATE

Card 3

- CONTROL EQUIPMENT AND EFFICIENCY FOR ALL CRITERIA POLLUTANTS

Card 4

- POINT ID
- FUEL HEAT CONTENT
- SULFUR
- ASH
- ESTIMATION METHOD
- POLLUTANT
- UNITS
- TIME INCREMENT
- START DATA
- START HOUR
- STOP DATE
- STOP HOUR
- THERMAL EFFICIENCY
- SCC NUMBER

Card 5/Type 1 - Hourly Process Data

- HOURLY DATA

Card 5/Type 2 - Hourly Emission Data

HOURLY DATA

Card 5/Type 3 - Annual Pattern

ANNUAL DATA
OPERATING PATTERN

Card 5/Type 4 - Non-Criteria Pollutants

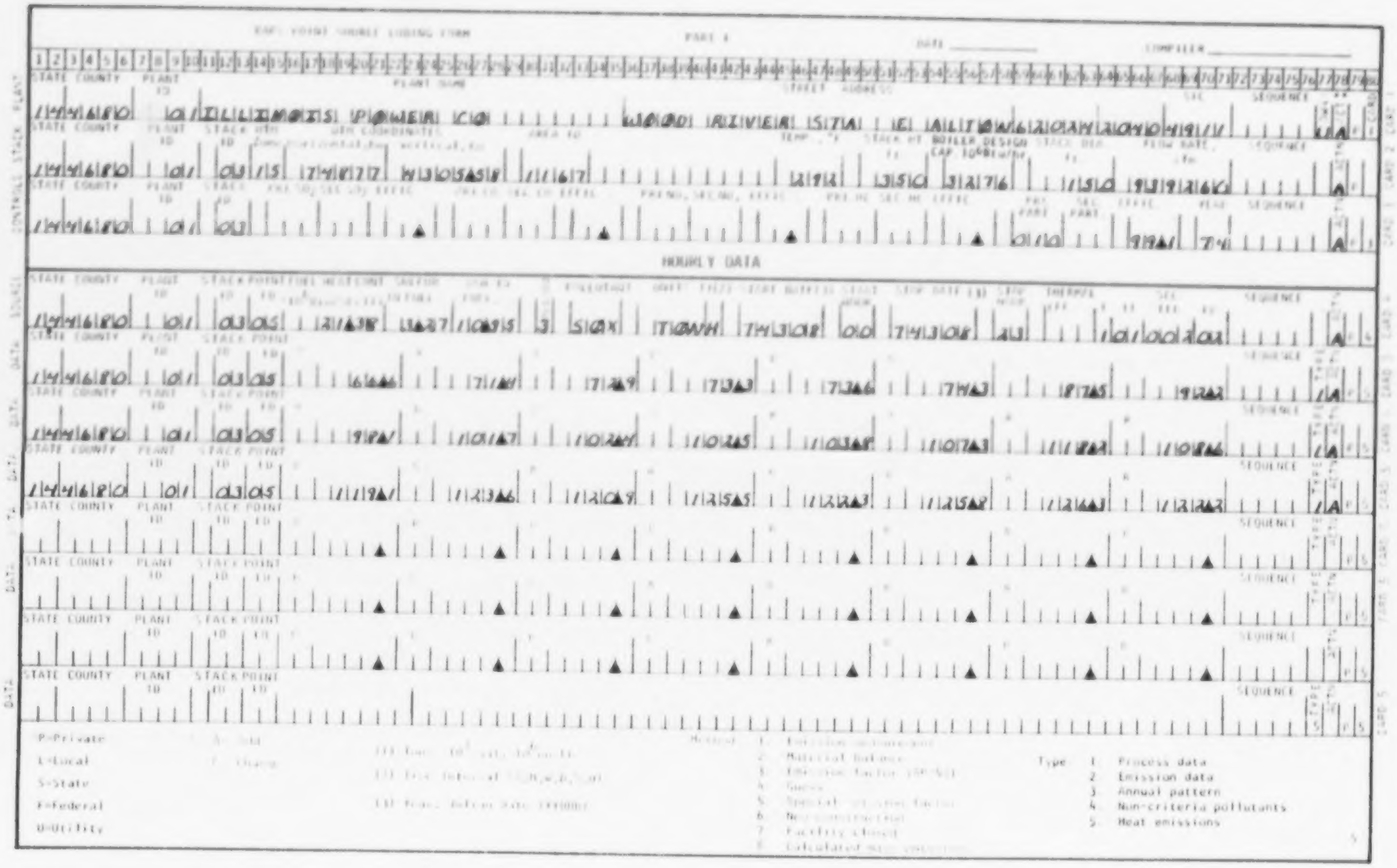
ANNUAL DATA
EMISSION FACTOR

Card 5/Type 5 - Emission Factors

EMISSION FACTOR

Card 6

COMMENTS



HOURLY DATA

STATE COUNTY PLANT ID PLANT NAME STREET ADDRESS SEQUENCE

ILLINOIS POWER CO WOOD RIVER STA E. ALTON

STATE COUNTY PLANT ID STACK ID UTM COORDINATES AREA ID TEMP., °F STACK HT BOILER DESIGN CAP STACK DIA. FLOW RATE SEQUENCE

STATE COUNTY PLANT ID STACK ID PRIME SEC NE EFFIC PRI PART SEC PART EFFIC YEAR SEQUENCE

STATE COUNTY PLANT ID STACK POINT ID SEQUENCE

P=Private
L=Local
S=State
F=Federal
U=Utility

Type:
1. Process data
2. Emission data
3. Annual pattern
4. Non-criteria pollutants
5. Heat emissions

FIGURE 14. RAPS POINT SOURCE CODING FORM - HOURLY DATA

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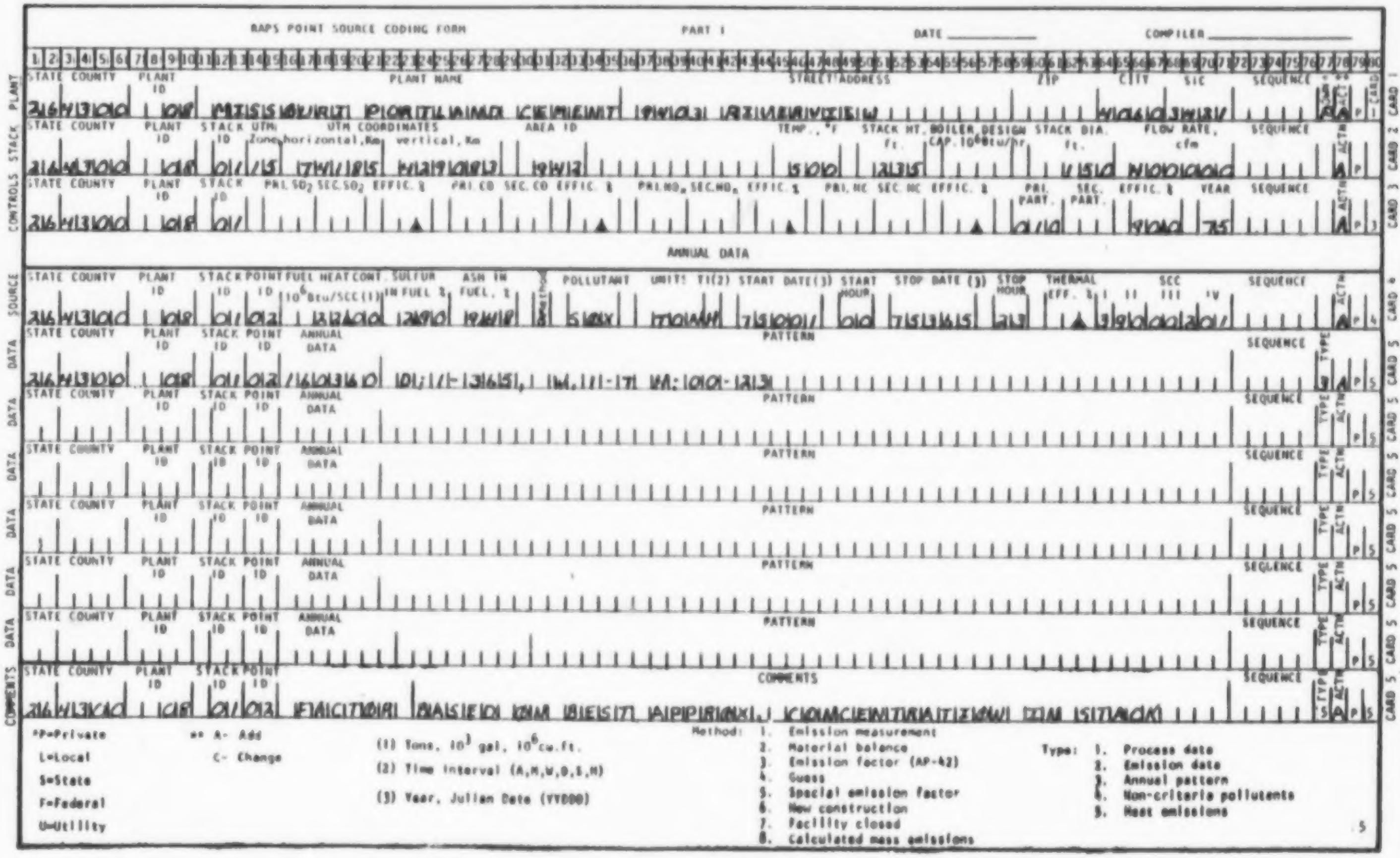


RAPS POINT SOURCE CODING FORM PART 1 DATE ________ COMPILER ________

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

PLANT — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | PLANT NAME: MISSOURI PORTLAND CEMENT | STREET ADDRESS: 9103 RIVERVIEW | ZIP | CITY: 4060 | SIC: 3241 | SEQUENCE | *: P | **ACT: A | P | CARD 1

STACK — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | STACK ID: 01 | UTM Zone: 15 | UTM COORDINATES horizontal, Km: 741.85 | vertical, Km: 4290.22 | AREA ID: 9412 | TEMP., °F: 500 | STACK HT. ft.: 235 | BOILER DESIGN CAP. 10⁶Btu/hr | STACK DIA. ft.: 15.0 | FLOW RATE, cfm: 400000 | SEQUENCE | ACTN: A | P | CARD 2

CONTROLS — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | STACK ID: 01 | PRI. SO₂ SEC. SO₂ EFFIC. % ▲ | PRI. CO SEC. CO EFFIC. % ▲ | PRI. NOₓ SEC. NOₓ EFFIC. % ▲ | PRI. HC SEC. HC EFFIC. % ▲ | PRI. PART.: 010 | SEC. PART. | EFFIC. %: 9900 | YEAR: 75 | SEQUENCE | ACTN: A | P | 3 | CARD 3

ANNUAL DATA

SOURCE — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | STACK ID: 01 | POINT ID: 02 | FUEL HEAT CONT. 10⁶ Btu/SCC(1): 23000 | SULFUR IN FUEL %: 290 | ASH IN FUEL, %: 948 | METHOD: 3 | POLLUTANT: SOX | UNIT! TI(2): TONSY | START DATE(3): 75001 | START HOUR: 00 | STOP DATE (3): 75365 | STOP HOUR: 23 | THERMAL EFF. %: ▲ | SCC I II III IV: 39000201 | SEQUENCE | ACTN: A | P | 4 | CARD 4

DATA — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | STACK ID: 01 | POINT ID: 02 | ANNUAL DATA: 160360 | PATTERN: D:1/1-365, M.1-7 W:00-23 | SEQUENCE | TYPE: 3 | ACTN: A | P | 5 | CARD 5

DATA — STATE COUNTY | PLANT ID | STACK ID | POINT ID | ANNUAL DATA | PATTERN | SEQUENCE | TYPE | ACTN | P | 5 | CARD 5

DATA — STATE COUNTY | PLANT ID | STACK ID | POINT ID | ANNUAL DATA | PATTERN | SEQUENCE | TYPE | ACTN | P | 5 | CARD 5

DATA — STATE COUNTY | PLANT ID | STACK ID | POINT ID | ANNUAL DATA | PATTERN | SEQUENCE | TYPE | ACTN | P | 5 | CARD 5

DATA — STATE COUNTY | PLANT ID | STACK ID | POINT ID | ANNUAL DATA | PATTERN | SEQUENCE | TYPE | ACTN | P | 5 | CARD 5

DATA — STATE COUNTY | PLANT ID | STACK ID | POINT ID | ANNUAL DATA | PATTERN | SEQUENCE | TYPE | ACTN | P | 5 | CARD 5

COMMENTS — STATE COUNTY: 26 4130 00 | PLANT ID: 08 | STACK ID: 01 | POINT ID: 02 | COMMENTS: FACTOR BASED ON BEST APPROX. CONCENTRATION ON STACK | SEQUENCE | TYPE: 5 | ACTN: A | P | 5 | CARD 5

*P=Private
L=Local
S=State
F=Federal
U=Utility

** A- Add
C- Change

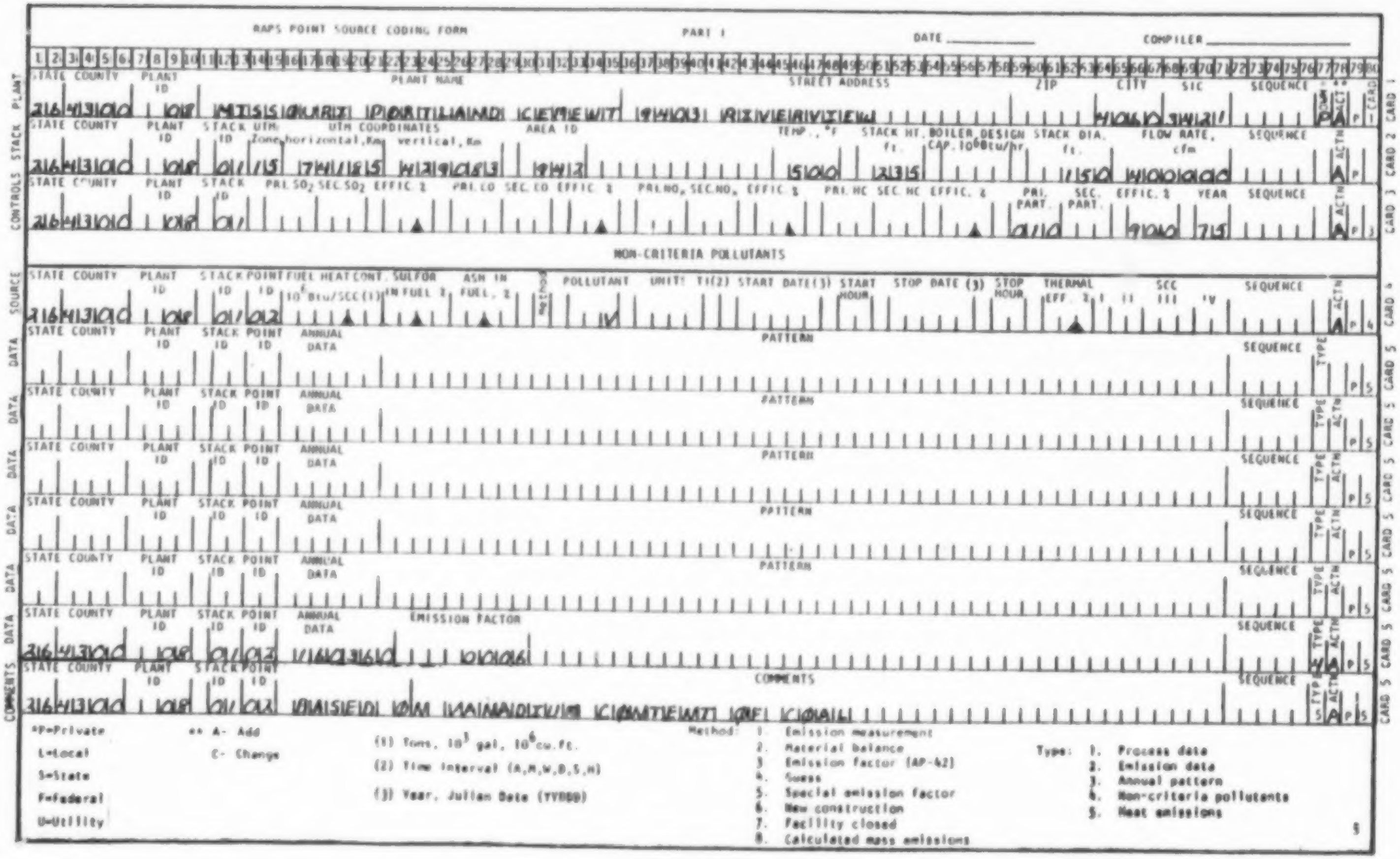
(1) Tons, $10^3$ gal, $10^6$ cu.ft.
(2) Time Interval (A,M,W,D,I,H)
(3) Year, Julian Date (YYDDD)

Method:
1. Emission measurement
2. Material balance
3. Emission factor (AP-42)
4. Guess
5. Special emission factor
6. New construction
7. Facility closed
8. Calculated mass emissions

Type:
1. Process data
2. Emission data
3. Annual pattern
4. Non-criteria pollutants
5. Heat emissions

5

FIGURE 15. RAPS POINT SOURCE CODING FORM - ANNUAL DATA



RAPS POINT SOURCE CODING FORM PART I DATE ____________ COMPILER ____________

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

PLANT: STATE 26 COUNTY 4300 PLANT ID 018 PLANT NAME MISSOURI PORTLAND CEMENT STREET ADDRESS 9403 RIVERVIEW ZIP CITY 4040 SIC 3241 SEQUENCE * P ** A CARD 1

STACK: STATE 26 COUNTY 4300 PLANT ID 018 STACK ID 01 UTM Zone 15 UTM COORDINATES horizontal, Km 74185 vertical, Km 429853 AREA ID 943 TEMP., °F 500 STACK HT. ft. 235 BOILER DESIGN CAP. 10⁶Btu/hr STACK DIA. ft. 150 FLOW RATE, cfm 400000 SEQUENCE ACTN A P CARD 2

CONTROLS: STATE 26 COUNTY 4300 PLANT ID 018 STACK ID 01 PRI. SO₂ SEC. SO₂ EFFIC. % PRI. CO SEC. CO EFFIC. % PRI. NOₓ SEC. NOₓ EFFIC. % PRI. HC SEC. HC EFFIC. % PRI. PART. 010 SEC. PART. EFFIC. % 990 YEAR 75 SEQUENCE ACTN A P 3 CARD 3

NON-CRITERIA POLLUTANTS

SOURCE: STATE 26 COUNTY 4300 PLANT ID 018 STACK ID 01 POINT ID 02 FUEL HEAT CONT. 10⁶ Btu/SCC(1) SULFUR IN FUEL % ASH IN FUEL, % METHOD POLLUTANT V UNIT(1) TI(2) START DATE(3) START HOUR STOP DATE (3) STOP HOUR THERMAL EFF. % SCC I II III IV SEQUENCE ACTN A P 4 CARD 4

DATA: STATE COUNTY PLANT ID STACK ID POINT ID ANNUAL DATA PATTERN SEQUENCE TYPE ACTN P 5 CARD 5

DATA: STATE COUNTY PLANT ID STACK ID POINT ID ANNUAL DATA PATTERN SEQUENCE TYPE ACTN P 5 CARD 5

DATA: STATE COUNTY PLANT ID STACK ID POINT ID ANNUAL DATA PATTERN SEQUENCE TYPE ACTN P 5 CARD 5

DATA: STATE COUNTY PLANT ID STACK ID POINT ID ANNUAL DATA PATTERN SEQUENCE TYPE ACTN P 5 CARD 5

DATA: STATE COUNTY PLANT ID STACK ID POINT ID ANNUAL DATA PATTERN SEQUENCE TYPE ACTN P 5 CARD 5

DATA: STATE 26 COUNTY 4300 PLANT ID 018 STACK ID 01 POINT ID 02 ANNUAL DATA 1400360 EMISSION FACTOR 00006 SEQUENCE TYPE 4 ACTN A P 5 CARD 5

COMMENTS: STATE 26 COUNTY 4300 PLANT ID 018 STACK ID 01 POINT ID 02 COMMENTS BASED ON VANADIUM CONTENT OF COAL SEQUENCE TYPE 5 ACTN A P 5 CARD 5

*P=Private
L=Local
S=State
F=Federal
U=Utility

** A- Add
C- Change

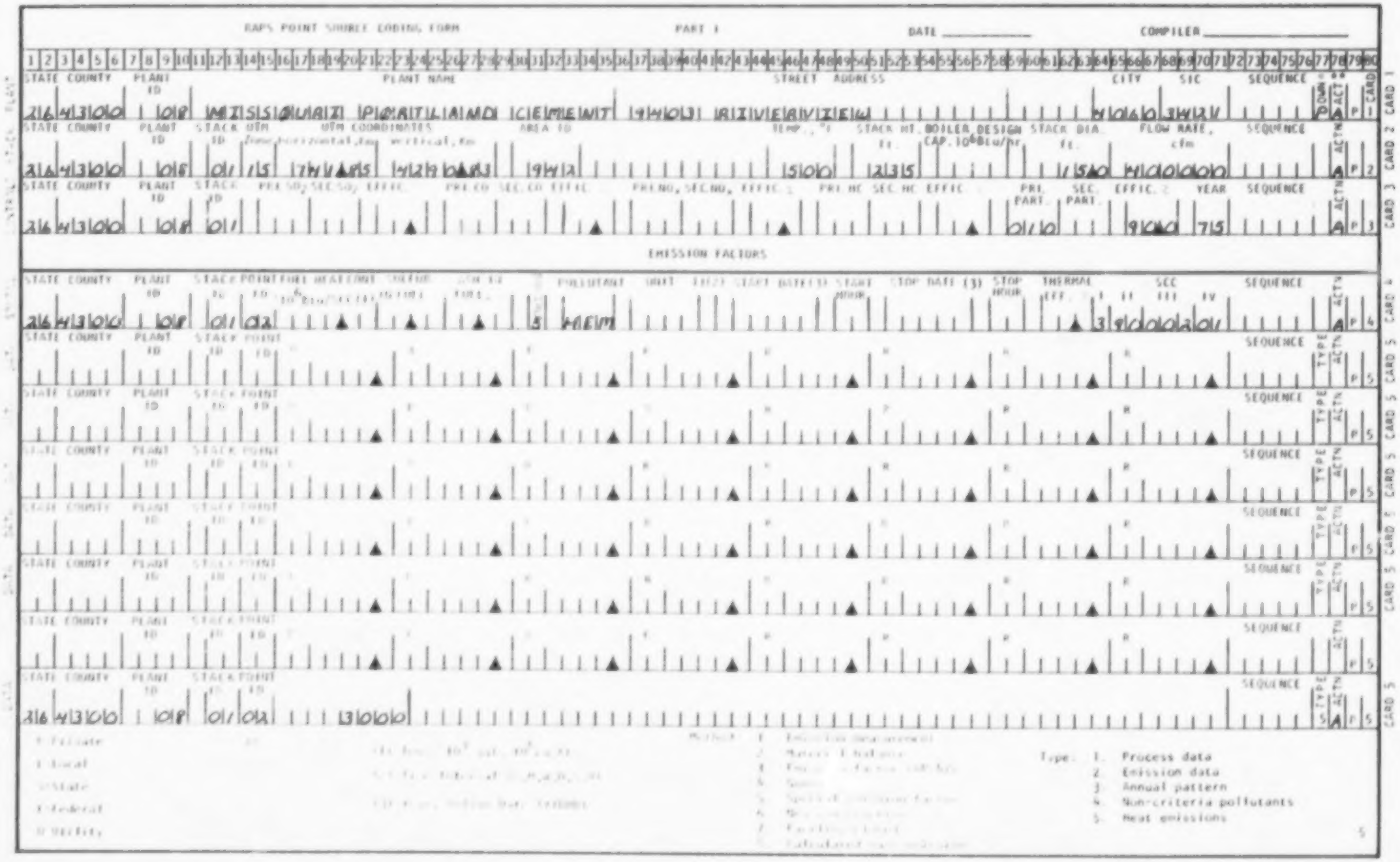
(1) Tons, $10^3$ gal, $10^6$ cu.ft.
(2) Time Interval (A,M,W,D,S,H)
(3) Year, Julian Date (YYDDD)

Method:
1. Emission measurement
2. Material balance
3. Emission factor (AP-42)
4. Guess
5. Special emission factor
6. New construction
7. Facility closed
8. Calculated mass emissions

Type:
1. Process data
2. Emission data
3. Annual pattern
4. Non-criteria pollutants
5. Heat emissions

5

FIGURE 16. RAPS POINT SOURCE CODING FORM - NON-CRITERIA POLLUTANTS



RAPS POINT SOURCE CODING FORM PART I DATE ______ COMPILER ______

STATE COUNTY | PLANT ID | PLANT NAME | STREET ADDRESS | CITY | SIC | SEQUENCE | OWN | ACT | CARD

26 43000 | 08 | MISSOURI PORTLAND CEMENT 9403 RIVERVIEW | 4060 | 3241 | P | A | 1

STATE COUNTY | PLANT ID | STACK ID | UTM Zone | UTM COORDINATES horizontal, km vertical, km | AREA ID | TEMP., °F | STACK HT. ft. | BOILER DESIGN CAP. 10⁶ Btu/hr | STACK DIA. ft. | FLOW RATE, cfm | SEQUENCE | ACTN

26 43000 | 08 | 01 | 15 | 942 | 500 | 235 | 15▲0 | 400000 | A | P | 2

STATE COUNTY | PLANT ID | STACK ID | PRI SO₂ SEC SO₂ EFFIC. | PRI CO SEC CO EFFIC. | PRI NO$_x$ SEC NO$_x$ EFFIC. | PRI HC SEC HC EFFIC. | PRI. PART. | SEC. PART. | EFFIC. | YEAR | SEQUENCE | ACTN

26 43000 | 08 | 01 | 010 | 75 | A | P | 3

EMISSION FACTORS

STATE COUNTY | PLANT ID | STACK ID | POINT ID | FUEL HEAT CONT. | SULFUR | ASH | POLLUTANT | UNIT | START DATE | START HOUR | STOP DATE | STOP HOUR | THERMAL EFF. | SCC I II III IV | SEQUENCE | ACTN

26 43000 | 08 | 01 | 02 | 5 | HEM | 39000201 | A | P | 4

STATE COUNTY | PLANT ID | STACK ID | POINT ID | SEQUENCE | TYPE | ACTN | P | 5

26 43000 | 08 | 01 | 02 | 3000 | 5 | A | P | 5

Private
Local
State
Federal
Utility

Type:
1. Process data
2. Emission data
3. Annual pattern
4. Non-criteria pollutants
5. Heat emissions

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FIGURE 17. RAPS POINT SOURCE CODING FORM - EMISSION FACTORS

## 2.2 EDITING OF DATA

The data are edited at several levels. The coding sheets are edited visually for numerical errors. The punched cards are verified for keypunch errors. They are then checked by editing programs, which check for correct syntax and proper limit of the entered values.

Every card is checked for certain "housekeeping" information, such as proper Card number (1-8), Source description (Point, Area, Line) and Action code (add or change).

_Card I_ is checked for proper ID codes for State (14 or 26), County, Plant, and City (>0).

_Card II_ is checked for Stack No. (>0), UTM zone (15 or 16) UTM coordinate for AQCR 70 (vertical between 4180 and 4330, horizontal between 640 and 770 for zone 15, 240 and 320 for zone 16) and area ID (between 1-1843, 2001-2465).

_Card IV_ is examined for proper Method code (0-8), Pollutant name (both criteria and non-criteria, including heat emissions) appropriate Unit and Time Intervals and legal SCC number.

_Card V_ is checked only if it is Type 3, when the program checks for correct syntax* of operating patterns.

_Card VI_ is checked only for "housekeeping data."

## 2.3 RAPS EMISSION INVENTORY CALCULATIONS

The data entered into the memory bank of the Univac 1100 at EPA-NERC are not emission values, but rather consumption or process figures from which mass emissions of pollutants can be calculated as part of the computer output routine. Only a few exceptional cases are emission concentrations recorded.

Data for major sources are calculated on an hourly basis; the inputs are usually based on hourly values, though in some cases only shift, daily, weekly or even monthly data are available. In all these cases an average hourly value is calculated by the computer.

---

*"Syntax" refers to a finite system of rules determining a rational structure of operating patterns.

Annual data are recorded for minor sources (producing between 1000 and 100 Tons $SO_2$ per year). The operating pattern (e.g. 5 days per week, 8 hours per day, closed for Holidays and a two week vacation period) is also recorded. An hourly average value is calculated by the computer based on the actual operating hours for each facility.

Base data are recorded in four different ways:

1. Fuel consumption (in tons, $10^3$ gal, $10^3$ or $10^6$ cu/ft)
2. Steam production ($10^3$ lbs steam per hour)
3. Power production (kw or mw)
4. Process rate (lb, ton, gal or bbl per hour)

In all cases the sulfur content of the fuel or material and the appropriate emission factor has to be known and recorded, either explicity or by reference to AP-42, "A compilation of Air Pollution Emission Factors".

Typical sample calculations for mass emission of $SO_2$ in lb/hour are shown below. All data are recorded in the units in which they are supplied; conversions to metric units, where desired, are performed by the computer as part of the output routine.

Example 1

SCC 1-01-002-02 A coal fired utility boiler

The following pertinent data are recorded:

| | | Example |
|---|---|---|
| FR .... | Firing rate, tons/hour | 30 |
| S .... | Aver. Sulfur analysis, % | 3.27 |
| | Calculation Method (referring to AP-42) | 3 |

Calculation:

$$E_{SO_2} = FR \times 38 \times S \qquad \text{where}$$

$E_{SO_2}$ = mass emission of $SO_2$ in lbs/hour, FR = firing rate (in tons/hour), and S = sulfur analysis in percent.

In this case

$$E_{SO_2} = 30 - 38 \times 3.27 = 3{,}727.8 \text{ lbs/hour}$$

Example 2

SCC 1-01-005-01    An oil-burning utility boiler

The following data are recorded:

| | | | Example |
|---|---|---|---|
| FR | .... | Firing rate, gal x $10^3$/hr | 1.9 |
| S | .... | Sulfur analysis, % | 0.40 |
| | | Calculation Method | 3 |

Calculation

$$E_{SO_2} = FR \times 144 \times S \qquad \text{where}$$

$E_{SO_2}$ = mass emission of $SO_2$, lbs/hour, FR = firing rate, $10^3$ gal/hour, and S = sulfur analysis in percent.

In this case,

$$E = 1.9 \times 144 \times 0.4 = 109.4 \text{ lb/hr}$$

If the firing rate is expressed in units other than $10^3$ gal/hour, such as, for example, $10^3$ gal/day, the computer will first convert this to an hourly rate, then proceed with the above calculation.

## Example 3

SCC 1-01-004-01 A residual-oil burning utility boiler
Only Power output is available

In some cases the firing rate has to be calculated from secondary data. In this case, the power output in megawatts per hour is the primary input.

The following data are recorded:

| | | | Example |
|---|---|---|---|
| P | .... | Power output, megawatt-hour/hour | 57 |
| H | .... | Heat content of fuel, $10^6$Btu/$10^3$gal | 152.30 |
| TE | .... | Thermal efficiency, overall, percent | 20.1 |
| S | .... | Sulfur analysis of fuel % | 3.47 |
| | | Calculation Method | 3 |

Since the theoretical conversion of MW hr to Btu is:

$$1 \text{ MW hr} \sim 3.413 \times 10^6 \text{ Btu},$$

the amount of fuel consumed per hour is

$$FR = \frac{P \times 3.413 \times 10^6 \times 100}{H \times TE}$$

Method 3 then gives the mass emission of $SO_2$ as

$$E_{SO_2} = \frac{P \times 3.413 \times 10^8}{H \times TE} \times 157 \times S,$$

or in this case,

$$E_{SO_2} = \frac{57 \times 3.413 \times 10^8}{152.3 \times 10^6 \times 20.1} \times 157 \times 3.47 = 3.462.1 \text{ lbs } SO_2/\text{hr}$$

Example 4

SCC 1 - 02-002-01 A coal-fired utility boiler.
Only power output is available.

This case is similar to example 3, but coal is the fuel. The recorded data are:

| | | Example |
|---|---|---|
| P .... | Power output, megawatt hours/hr | 507 |
| H .... | Heat content of fuel, $10^6$ Btu/Ton | 22.12 |
| TE .... | Thermal efficiency, overall, percent | 38.1 |
| S .... | Sulfur analysis of fuel | 2.5 |
| | Calculation method | 3 |

Again, the theoretical conversion rate is:

$$1 \text{ MWhr} = 3.413 \times 10^6 \text{ Btu}$$

Therefore, the amount of fuel consumed is

$$FR = \frac{P \times 3.413 \times 10^6 \times 10^2}{H \times TE} \quad \text{tons per hour,}$$

and the mass emission of $SO_2$ according to AP-42 (Method 3) is

$$E_{SO_2} = \frac{P \times 3.413 \times 10^8}{H \times TE} \times 38 \times S$$

In our example

$$E_{SO_2} = \frac{507 \times 3.413 \times 10^8 \times 38 \times 2.5}{22.12 \times 10^6 \times 38.1} = 19{,}505 \text{ lb/hr}$$

## Example 5

SCC 1-02-002-09 An industrial coal fired boiler
Only steam production data are available.

The following data are recorded:

| | | | Example |
|---|---|---|---|
| SP | .... | Steam production, lb/hour x $10^3$ | 42 |
| H | .... | Heat content of fuel, $10^6$ Btu/ton | 21.39 |
| TE | .... | Thermal efficiency (boiler only), % | 80.01 |
| S | .... | Sulfur analysis of fuel, percent | 2.9 |
| | | Calculation method | 3 |

The conversion from steam production to the weight of coal fired (FR) is

$$FR = \frac{SP \times 1202 \times 100}{TE \times H} \text{ tons coal/hr}$$

(The conversion factor 1202 converts pounds of steam (300 psi, saturated) to BTU. The thermal efficiency factor, as recorded on the cards, includes an adjustment to the actual steam conditions.)

The mass emission of sulfur dioxide, using method 3 (AP-42) is

$$E_{SO_2} = \frac{SP \times 1202 \times 100 \times 38 \times S}{TE \times H}$$

In our example

$$E_{SO_2} = \frac{42 \times 10^3 \times 1202 \times 10^2 \times 38 \times 2.9}{80.1 \times 21.39 \times 10^6} = 325.0 \text{ lbs/hr}$$

Example 6

SCC 3-01-023-99 Sulfuric Acid manufacture. $SO_2$ concentration and exhaust gas volume are available.

In this case, the concentration of $SO_2$ in the stack gases in continuously recorded. The flow of stack gases is nominally constant but no record is available.

The recorded data are

| | | | Example |
|---|---|---|---|
| C | .... | $SO_2$ concentration, ppm (vol) | 1400 |
| F | .... | stack gas flow, cu ft/min x $10^3$ | 31 |

Thus, hourly mass emission of $SO_2$

$$E_{SO_2} = \frac{F \times 60 \times C \times 0.178}{10^6} \text{ lbs } SO_2\text{/hr}$$

The factor 0.178 is the weight of 1 cu ft of $SO_2$ (in lbs) under standard conditions.

In our example

$$E_{SO_2} = \frac{31 \times 10^3 \times 60 \times 1400 \times 0.178}{10^6} = 463.5 \text{ lbs/hour}$$

# 3.0 PRESENTATION OF DATA

The inventory data are available in a number of formats. Several of these were designed to parallel NEDS formats: Point Source Listings, Annual County, State and AQCR Summaries. Others are unique to RAPS, such as Hourly, Daily and Monthly Point Source listings. In addition, a basic modeler's tape output is available, which contains information of particular interest to modelers in an unlabeled 80 character per record format.

Examples of the various output formats are shown in Figure 18 to 24. Figure 18 shows a complete point source listing, giving all descriptive information for a single source, as well as hourly emissions for five criteria pollutants. Figure 19 gives similar descriptive information, but is a sample of a daily summary for pollutants. Figure 20 is similar giving the annual output of the same point source; Figure 21 shows a modeler's tape. It shows hourly outputs for five pollutants, Particulates, $SO_2$, $NO_X$, hydrocarbons, and CO in pounds per hour as well as stack gas flow in SCFM, for three points for Julian day 75 001 (1 Jan 1975). The plant is uniquely identified by State (26), County (1680) and number (03). Each of the three points is further identified by another number (01-03). Other information contained on the same line as grid ID (74) SIC code (4911), UTM coordinates in Zone 15 (688.37, 4270.23), stack height (700 ft.), stack diameter (20.5 ft.) and stack temperature (285°F). The information is repeated for each point. Daily totals for the plant appear on the last line. Figure 22 gives total annual emissions for a county (Madison County, 14-4680) for all criteria pollutants, broken down into major categories. Figure 23 gives all criteria pollutants for the major categories for a State, (Illinois). Finally, Figure 24 shows a listing of emissions for the whole Air Quality Control Region 70, again aggrated into the major source categories.

```
                              ******************************
                              *    POINT SOURCE LISTING    *
                              ******************************
                       03:  UNION ELECTRIC CO                          STACK ID: 01
                            HIGHWAY M  LABADIE      63055               POINT ID: 01
                     5200: MISSING STATE OR CITY CODE                   SIC: 4911
                     1680: FRANKLIN CO                                  AREA ID:   74
                       26: MISSOURI                                     OWNERSHIP: UTILITY
               SCC(1-01-002-01):EXTCOMB BOILER   - ELECTRIC GENERATN- BITUMINOUS COAL  - >100MMBTU PULVWET

         UTM GRID COORDINATES     STACK PARAMETERS             EMISSION METHODS        FUEL CONTENT
         ********************     *****************            *****************       ************
         UTM ZONE: 15             STACK HEIGHT:  700 FT        PART:  AP-42            SULFUR:  2.68 %
         HORIZONTAL: 688.37 KM    STACK DIAMETER:  20.5 FT     SOX:   AP-42            ASH:     10.28 %
         VERTICAL:   4270.23 KM   GAS TEMPERATURE:  285 F      NOX:   AP-42            HEAT:    21.70 MBTU/SCC
                                  GAS FLOW RATE: 1600000 CFM   HC:    AP-42
                                  BOILER CAPACITY:5387 MBTU/HR CO:    AP-42

                                               CONTROL EQUIPMENT
                                               *****************

*PRIMARY CONTROLS*                                    *SECONDARY CONTROLS*                                *EFFICIENCIES*
PART: ELECTROSTATIC PRECIPITATOR-HIGH EFFICIENCY      PART: NO EQUIPMENT                                      99.5 %
SOX:  NO EQUIPMENT                                    SOX:  NO EQUIPMENT                                        .0 %
NOX:  NO EQUIPMENT                                    NOX:  NO EQUIPMENT                                        .0 %
HC:   NO EQUIPMENT                                    HC:   NO EQUIPMENT                                        .0 %
CO:   NO EQUIPMENT                                    CO:   NO EQUIPMENT                                        .0 %

                                          * * * * EMISSIONS IN LBS * * * *

   DATE       HOUR           PART           SOX            NOX             HC              CO
 ********     ****        **********     **********     **********      **********      **********

  1/ 1/75       0            95.44        14546.08        4284.98          42.85          142.83
  1/ 1/75       1            95.16        14504.04        4272.60          42.73          142.42
  1/ 1/75       2            95.16        14504.04        4272.60          42.73          142.42
  1/ 1/75       3            94.89        14462.00        4260.21          42.60          142.01
  1/ 1/75       4            95.44        14546.08        4284.98          42.85          142.83
  1/ 1/75       5            95.72        14588.12        4297.37          42.97          143.25
  1/ 1/75       6            95.44        14546.08        4284.98          42.85          142.83
  1/ 1/75       7            95.44        14546.08        4284.98          42.85          142.83
  1/ 1/75       8            96.27        14672.20        4322.13          43.22          144.07
  1/ 1/75       9            96.54        14714.25        4334.52          43.35          144.48
  1/ 1/75      10            96.82        14756.29        4346.90          43.47          144.90
  1/ 1/75      11            96.82        14756.29        4346.90          43.47          144.90
  1/ 1/75      12            96.82        14756.29        4346.90          43.47          144.90
  1/ 1/75      13            97.10        14798.33        4359.29          43.59          145.31
  1/ 1/75      14           117.23        17867.30        5263.34          52.63          175.44
  1/ 1/75      15           117.23        17867.30        5263.34          52.63          175.44
  1/ 1/75      16           118.61        18077.50        5325.27          53.25          177.51
  1/ 1/75      17           118.06        17993.42        5300.50          53.00          176.68
  1/ 1/75      18           117.78        17951.38        5288.11          52.88          176.27
  1/ 1/75      19           118.34        18035.46        5312.88          53.13          177.10
  1/ 1/75      20           118.61        18077.50        5325.27          53.25          177.51
  1/ 1/75      21           117.78        17951.38        5288.11          52.88          176.27
  1/ 1/75      22           116.96        17825.26        5250.96          52.51          175.03
  1/ 1/75      23           117.51        17909.34        5275.73          52.76          175.86
```

FIGURE 18.  POINT SOURCE LISTING - HOURLY

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```
12/17/76
                         R A P S   S T .   L O U I S   E M I S S I O N   I N V E N T O R Y

                                        ********************************
                                        *     POINT SOURCE LISTING     *
                                        ********************************

                          03:  UNION ELECTRIC CO                         STACK ID: 01
                               HIGHWAY M  LABADIE      63055             POINT ID: 01
                        5200:  MISSING STATE OR CITY CODE                SIC: 4911
                        1680:  FRANKLIN CO                               AREA ID:    74
                          26:  MISSOURI                                  OWNERSHIP: UTILITY

              SCC(1-01-002-01):EXTCOMB BOILER   - ELECTRIC GENERATN- BITUMINOUS COAL  - >100MMBTU PULVWET

         UTM GRID COORDINATES     STACK PARAMETERS              EMISSION METHODS         FUEL CONTENT
         *********************    ****************              *****************        ************
         UTM ZONE: 15             STACK HEIGHT:  700 FT         PART:   AP-42            SULFUR:   2.68 %
         HORIZONTAL: 688.37 KM    STACK DIAMETER:  20.5 FT      SOX:    AP-42            ASH:      10.28 %
         VERTICAL:  4270.23 KM    GAS TEMPERATURE:  285 F       NOX:    AP-42            HEAT:     21.70 MBTU/SCC
                                  GAS FLOW RATE: 1600000 CFM    HC:     AP-42
                                  BOILER CAPACITY:5387 MBTU/HR  CO:     AP-42

                                              CONTROL EQUIPMENT
                                              *****************

   *PRIMARY CONTROLS*                                  *SECONDARY CONTROLS*                          *EFFICIENCIES*
   PART: ELECTROSTATIC PRECIPITATOR-HIGH EFFICIENCY    PART: NO EQUIPMENT                                99.5 %
   SOX:  NO EQUIPMENT                                  SOX:  NO EQUIPMENT                                  .0 %
   NOX:  NO EQUIPMENT                                  NOX:  NO EQUIPMENT                                  .0 %
   HC:   NO EQUIPMENT                                  HC:   NO EQUIPMENT                                  .0 %
   CO:   NO EQUIPMENT                                  CO:   NO EQUIPMENT                                  .0 %

                                           * * * * EMISSIONS IN LBS * * * *

       DATE                     PART          SOX             NOX             HC              CO
     ********                ***********   ***********     ***********     ***********     **********

      1/ 1/75                  2521.18     384251.99       113192.85         1131.93         3773.10


                                             **** E N D ****
```

FIGURE 19. POINT SOURCE LISTING - DAILY

```
12/16/76
                        R A P S   S T .   L O U I S   E M I S S I O N   I N V E N T O R Y

                                   ********************************
                                   * ANNUAL POINT SOURCE LISTING *
                                   ********************************

                       03:  UNION ELECTRIC CO                              STACK ID: 01
                            HIGHWAY M  LABADIE      63055                  POINT ID: 01
                     5200: MISSING STATE OR CITY CODE                      SIC: 4911
                     1680: FRANKLIN CO                                     AREA ID:   74
                       26: MISSOURI                                        OWNERSHIP: UTILITY

              SCC(1-01-002-01):EXTCOMB BOILER   - ELECTRIC GENERATN- BITUMINOUS COAL  - >100MMBTU PULVWET

          UTM GRID COORDINATES      STACK PARAMETERS                  EMISSION METHODS            FUEL CONTENT
          ********************      ****************                  ****************            ************
          UTM ZONE: 15              STACK HEIGHT:  700 FT             PART:  AP-42                SULFUR:  2.89 %
          HORIZONTAL: 688.37 KM     STACK DIAMETER:  20.5 FT          SOX:   AP-42                ASH:     10.50 %
          VERTICAL:  4270.23 KM     GAS TEMPERATURE:  285 F           NOX:   AP-42                HEAT:    21.87 MBTU/SCC
                                    GAS FLOW RATE: 1600000 CFM        HC:    AP-42
                                    BOILER CAPACITY:5387 MBTU/HR      CO:    AP-42
                                                 CONTROL EQUIPMENT
                                                 *****************
                                                                                                       *EFFICIENCIES*
      *PRIMARY CONTROLS*                                *SECONDARY CONTROLS*                               99.5 %
      PART: ELECTROSTATIC PRECIPITATOR-HIGH EFFICIENCY   PART: NO EQUIPMENT                                  .0 %
      SOX:  NO EQUIPMENT                                 SOX:  NO EQUIPMENT                                  .0 %
      NOX:  NO EQUIPMENT                                 NOX:  NO EQUIPMENT                                  .0 %
      HC:   NO EQUIPMENT                                 HC:   NO EQUIPMENT                                  .0 %
      CO:   NO EQUIPMENT                                 CO:   NO EQUIPMENT

                                              * * * * EMISSIONS IN TONS * * * *

         YEAR OF                    PART          SOX           NOX           HC            CO
         *******                 **********    **********    **********    **********    **********

          1975                     388.04       62501.91      17061.27       170.61        568.71
```

FIGURE 20.  POINT SOURCE LISTING - ANNUAL

```
  74                     75001 75001   JPRINT 12-16-76 18:23:38
26168003  01  744911 688.374270.23 70020.5 285
        95.44      14546.08      4284.98           42.85        142.83     920577.60
        95.16      14504.04      4272.60           42.73        142.42     917916.98
        95.16      14504.04      4272.60           42.73        142.42     917916.98
        94.89      14462.00      4260.21           42.60        142.01     915256.36
        95.44      14546.08      4284.98           42.85        142.83     920577.60
        95.72      14588.12      4297.37           42.97        143.25     923238.24
        95.44      14546.08      4284.98           42.85        142.83     920577.60
        95.44      14546.08      4284.98           42.85        142.83     920577.60
        96.27      14672.20      4322.13           43.22        144.07     928559.49
        96.54      14714.25      4334.52           43.35        144.48     931220.12
        96.82      14756.29      4346.90           43.47        144.90     933880.75
        96.82      14756.29      4346.90           43.47        144.90     933880.75
        96.82      14756.29      4346.90           43.47        144.90     933880.75
        97.10      14798.33      4359.29           43.59        145.31     936541.39
       117.23      17867.30      5263.34           52.63        175.44    1130767.30
       117.23      17867.30      5263.34           52.63        175.44    1130767.30
       118.61      18077.50      5325.27           53.25        177.51    1144070.44
       118.06      17993.42      5300.50           53.00        176.68    1138749.17
       117.78      17951.38      5288.11           52.88        176.27    1136088.56
       118.34      18035.46      5312.88           53.13        177.10    1141409.80
       118.61      18077.50      5325.27           53.25        177.51    1144070.44
       117.78      17951.38      5288.11           52.88        176.27    1136088.56
       116.96      17825.26      5250.96           52.51        175.03    1128106.67
       117.51      17909.34      5275.73           52.76        175.86    1133427.92
26168003  02  744911 688.404270.20 70020.5 285
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
          .00           .00          .00             .00           .00           .00
26168003  03  744911 688.454270.10 70029.0 285
       243.84      37163.98     10947.76          109.48        364.93    2534293.87
       244.39      37248.06     10972.52          109.73        365.75    2540027.59
       244.39      37248.06     10972.52          109.73        365.75    2540027.59
       244.39      37248.06     10972.52          109.73        365.75    2540027.59
       242.19      36911.74     10873.45          108.73        362.45    2517092.78
       244.12      37206.02     10960.14          109.60        365.34    2537160.72
       239.43      36491.33     10749.61          107.50        358.32    2488424.31
       238.60      36365.21     10712.45          107.12        357.08    2479823.78
       238.33      36323.17     10700.07          107.00        356.67    2476956.91
       238.05      36281.12     10687.68          106.88        356.26    2474090.06
       241.64      36827.65     10848.68          108.49        361.62    2511359.12
       242.46      36953.78     10885.83          108.86        362.86    2519959.66
       243.57      37121.94     10935.37          109.35        364.51    2531427.03
       236.40      36028.88     10613.38          106.13        353.78    2456889.00
       243.02      37037.86     10910.60          109.11        363.69    2525693.34
       240.81      36701.53     10811.53          108.12        360.38    2502758.56
       232.26      35398.27     10427.61          104.28        347.59    2413086.22
       221.78      33800.72      9957.01           99.57        331.90    2304946.00
       222.88      33968.89     10006.55          100.07        333.55    2316413.41
       234.74      35776.64     10539.07          105.39        351.30    2439687.87
       238.60      36365.21     10712.45          107.12        357.08    2479823.75
       239.43      36491.33     10749.61          107.50        358.32    2488424.31
       239.71      36533.37     10761.99          107.62        358.73    2491291.19
       238.88      36407.25     10724.84          107.25        357.49    2482690.62
999999
      8255.08    1258151.89    370626.03         3706.26      12354.20
ENDJOB
```

FIGURE 21. MODELER'S TAPE

```
144680   01976JPRINT

                                   *******************************************************
                                   * RAPS POINT SOURCE SUMMARY EMISSIONS REPORT  12-19-77 *
                                   *******************************************************

                                          EMISSIONS FROM MADISON CO,ILLINOIS

                                            EMISSIONS IN TONS/YEAR FOR 1976

           FUEL COMBUSTION                    PART          SOX          NOX           HC           CO
           **** **********              **********   **********   **********   **********   **********
             EXTCOMB BOILER
               ELECTRIC GENERATN
                 BITUMINOUS COAL           2318.92     36260.84      8576.99       145.46       584.92
                 DISTILLATE OIL              37.38       536.01       940.31        17.66        26.76
                 NATURAL GAS                 10.07          .71       562.50         1.18        15.88
                 TOTAL(ELECTRIC GENER)     2366.37     36797.56     10079.81       164.30       627.56

               INDUSTRIAL
                 BITUMINOUS COAL            211.41     12071.23      1786.86        29.78        99.27
                 RESIDUAL OIL                77.99       781.27       283.77        14.19        18.92
                 DISTILLATE OIL               6.55        22.93        26.19         1.31         1.75
                 NATURAL GAS                 15.30       154.28       542.46         5.40        30.58
                 OTHER/NOT CLASIFD           63.00      2254.00      1856.00          .00          .00
                 TOTAL(INDUSTRIAL           374.24     15283.71      4495.28        50.68       150.52

               COMMERCL-INSTUTNL
                 BITUMINOUS COAL              7.84        44.09         2.14         1.07         3.57
                 RESIDUAL OIL                 3.04        69.83        16.68          .83         1.11
               TOTAL(EXTCOMB BOILER)       2751.49     52195.19     14593.91       216.88       782.76
             TOTAL(FUEL COMBUSTION)        2751.49     52195.19     14593.91       216.88       782.76

           INDUSTRIAL PROCESS
           ********** *******
               CHEMICAL MFG                    .00      2520.00          .00          .00          .00
               PRIMARY METALS              2756.61      3620.00       978.00      1998.00     48188.74
               SECONDARY METALS             449.06       506.20        24.30          .00          .00
               MINERAL PRODUCTS             513.19          .00          .00          .00          .00
               PETROLEUM INDRY             1826.76     31670.71      3794.15      6991.68     70632.81
               INPROCESS FUEL                  .08          .31       631.49          .00          .00
               SURFACE COATING                 .00          .00          .00      1822.00          .00
               PETROLEUM STG                   .00          .00          .00      3096.89          .00
               PETROL MRKT-TRANS               .00          .00          .00      1271.34          .00
               MISC HC EVAP
                 OTHER/NOT CLASIFD             .00          .00          .00         4.00          .00
               TOTAL                       5545.69     38317.23      5427.94     15183.92    118821.55

             GRAND TOTAL                   8297.18     90512.42     20021.85     15400.80    119604.32

                                                 ****  E N D  ****
EOF:51
0:>
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FIGURE 22. POINT SOURCE SUMMARY REPORT - COUNTY (MADISON)

```
                              ***********************************************************
                              * RAPS POINT SOURCE SUMMARY EMISSIONS REPORT  09-13-77 *
                              ***********************************************************

                                     AQCR(070):METROPOLITAN ST. LOUIS (ILL-MO)

                                          EMISSIONS IN TONS/YEAR FOR 1976

FUEL COMBUSTION                      PART           SOX           NOX            HC            CO
**** **********                ********** ********** ********** ********** **********
  EXTCOMB BOILER
    ELECTRIC GENERATN
      BITUMINOUS COAL                8182.17     851075.96     285377.11       2375.93       8011.58
      RESIDUAL OIL                     14.81       4070.60       1281.10         24.40         36.60
      DISTILLATE OIL                   38.04        548.53        969.57         18.22         27.59
      NATURAL GAS                      10.72           .83        609.30          1.39         19.34
      TOTAL(ELECTRIC GENER)          8245.74     855695.91     288237.09       2419.94       8095.12

    INDUSTRIAL
      BITUMINOUS COAL                1541.33      28949.64       4172.56        160.40        377.64
      RESIDUAL OIL                    135.07       4191.46       1018.14         50.71         67.38
      DISTILLATE OIL                    8.85         31.65         35.40          1.77          2.36
      NATURAL GAS                      80.78        171.30       9340.02         55.27        312.06
      PROCESS GAS                        .00        116.31           .00           .00           .00
      OTHER/NOT CLASIFD                63.00       2251.00       1858.00           .00           .00
      TOTAL(INDUSTRIAL    )          1829.02      35711.36      16424.12        268.14        759.44

    COMMERCL-INSTUTNL
      BITUMINOUS COAL                1499.66       1592.04        195.81         13.98         29.39
      RESIDUAL OIL                     46.24        344.23        129.39          6.47          8.63
      DISTILLATE                         .86          6.84          7.23           .36           .48
      NATURAL GAS                       5.01           .37         76.04          4.87         12.17
      TOTAL(COMMERCL-INSTU)          1551.77       1943.48        408.47         25.68         50.67
    TOTAL(EXTCOMB BOILER)           11626.54     893350.70     305069.65       2713.76       8905.23

  INTERNLCOMBUSTION
    ELECTRIC GENERATN
      DISTILLATE OIL                     .29          1.60          3.86           .32           .88
      NATURAL GAS                        .89           .00         26.23          2.67          7.30
      DIESEL                             .25           .03          7.03           .70          4.27
      TOTAL(ELECTRIC GENER)             1.42          1.62         37.12          3.69         12.46

    TOTAL(INTERNLCOMBUST)               1.42          1.62         37.12          3.69         12.46
  TOTAL(FUEL COMBUSTION)            11627.96     893352.31     305106.77       2717.45       8917.68

INDUSTRIAL PROCESS
********** *******
      CHEMICAL MFG                     16.72       5483.59       2748.20       6701.50      31000.00
      FOOD/AGRICULTURAL                77.36           .00           .00           .00           .00
      PRIMARY METALS                 2871.41      36262.98        984.43       2338.94      48190.78
      SECONDARY METALS                504.82        970.20         24.30           .00       2410.48
      MINERAL PRODUCTS              26948.59      15670.89       5215.83           .00           .00
      PETROLEUM INDRY                2858.35      55562.58       7337.57       7161.38      70632.81
      INPROCESS FUEL                     .08           .41       1131.30           .00           .00
      CLEANING SOLVENT                   .00           .00           .00         20.40           .00
      SURFACE COATING                    .00           .00           .00      21072.97           .00
      PETROLEUM STG                      .00           .00           .00       3927.33           .00
      PETROL MRKT-TRANS                  .00           .00           .00       3529.94           .00
      MISC HC EVAP                       .00           .00           .00          4.00           .00
      TOTAL(INDUSTRIAL)             33277.35     113950.65      17441.62      44756.46     152234.07

SOLID WASTE DISPOSAL
***** ***** ********
      GOVERNMENT
        MUNICIPAL INCIN               318.92        227.15        181.72        136.29       3180.10
      TOTAL(SOLID WASTE   )           318.92        227.15        181.72        136.29       3180.10

  GRAND TOTAL                       45224.22    1007530.09     322730.10      47610.19     164331.86

                                             ****  E N D  ****
EOF:72
01>
```

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FIGURE 24. POINT SOURCE SUMMARY REPORT - AQCR 70

## REFERENCES

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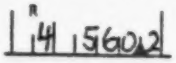
# APPENDIX A

## GENERAL INSTRUCTIONS

1. Cards 1, 2 and 3 need to be made out only once; after that a point source is fully identified by the first 15 spaces on each card.

2. A card 4 must precede each set of cards 5. The Time Interval (TI) on card 4 defines the period (hour, shift, date, etc.) covered by each entry is in card 5. Similarly, the Start Date and Stop Date entries define the time covered by the entries in card 5. All hours included between Start Date and Stop Date must be accounted for as one or more card 5's.

3. If a value is repeated more than once, the spaces under R may be used to indicate the number of repetitions, followed by the value which is to be repeated: e.g.,



for 560.2 repeated 4 times

4. Daily data, indicated by a D in time interval space on Card 4, may be repeated just like hourly data, with the number of repetitions under R. Also, a full month of data may be entered on a single sheet by using the start and stop date to span the period and accounting for each day with individual entries or with repeats.

5. On each data card (card 5) the type of data (Process data, Emission data, etc.) and the action (Add or Change) should be entered.

6. Any appropriate comments can be entered on card 6, which should be preceded by both a card 4 and card 5.

7. The sequence number will be entered just prior to delivery for key punching.

## AMAX Zinc Co. - Sauget, Illinois (618) 274-5000

Illinois - 14, St. Clair Co. - 6900, Sauget - 9010, Plant - 38

**Location**: Rt. 3, just south of Poplar Street bridge

**Personnel**: Ken Carpenter - engineer - our contract
J. Gorman - plant manager

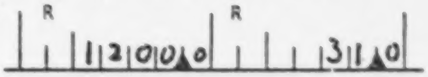
**Data Acquisition**: by mail monthly

**Data Description**: table of hourly $SO_2$ stack concentration

**Data Handling**:

1) On each coding form, record appropriate ID's, method-1, pollutant-$SO_x$, units-ppm, time interval of data, appropriate julian dates, SCC number and action. Data type - 2

2) Data is entered piggy-back style with the $SO_2$ concentration first followed by the flow rate - 31.0 for 31,000 s.c.f.m., e.g.:



R 1200.0 R 31.0

3) If the entry is repeated, the number of repetitions is only necessary in front of the concentration, not the flow rate.

## AMOCO Oil Refinery - (618) 254-7351

Illinois - 14, Madison Co. - 4680, Wood River - 8520, Plant - 04

Location: Int. 270 East, north on Ill. 3 to Wood River

Personnel: Mr. Bob Yoder, engineer - our contact
Mr. Ed Sullivan, plant environmental engineer
Mr. F. K. Webb, plant manager

Data Acquisition: monthly, by mail

Data Description: daily totals of fuel consumption by unit, fuel consumption at power house, thruput for fluid cracker, $SO_2$ emissions at flares

Data Handling:

1) See attached sheets for explanation of each unit.
2) On each coding form; record appropriate ID's; current average fuel analysis; method - 3,5 or 8; pollutant - S0X; data units - CFT, GAL, BBL, LB; time interval of entered data; appropriate julian date, SCC number, and action
3) Most data are daily values, therefore a whole month may be put on one sheet by recording each daily amount.
4) Gas analysis heat content is $10^6$ Btu/$10^3$ft$^3$, e.g.: 992.5 Btu/ft$^3$ → 0.99 $10^6$ Btu/$10^3$ft$^3$

Data Handling - by Unit:

Power Station: Boilers 1, 3, 5 burn all four fuels simultaneously
Boilers 2, 4, 6 do not burn slop oil

| | Boiler 1 | Boiler 2 | Boiler 3 | Boiler 4 | Boiler 5 | Boiler 6 |
|---|---|---|---|---|---|---|
| % of Total | 12.2 | 14.2 | 15.0 | 17.2 | 21.0 | 20.4 |
| % of Slop Oil | 25.3 | | 31.1 | | 43.6 | |

For each boiler, multiply given percentage by daily fuel consumption figure and record. Use separate sheets for each fuel and each unit.

For hydrogen gas and slop oil, determine a monthly average and use this figure rather than the daily numbers. For these fuels use the start and stop dates to cover the whole month with one coding form.

Determine a monthly average fuel analysis for each fuel. For gaseous fuels, the volumetric percent of $H_2S$ must be converted to weight percent sulfur. Use the conversion:

$$1\%\ H_2S = 1.577\ \%S$$

A special emission factor (method 5) will be used with the gaseous fuels:

$$F = 1.069\ S$$

## #5 Pipe Still (stack 07)

This unit burns No. 5 PS AOG (Absorber Off-Gas) Refining Gas and Asphalt. The No. 5 PS AOG is assumed to be 679,100 cf/day with a heat content the same as refinery gas.

The Refinery Gas usage is determined by subtracting 679,100 from the given daily amount of Refinery Gas. This will have the same analysis as the gas used at the Power Station.

The asphalt usage is converted from barrels/day to thousands of gallons/day and recorded. Asphalt is recorded as if it was fuel oil. Use method 5 for asphalt.

## Reformer and Desulfurizer (stacks 09, 10, 12, 14)

### Stack #14

The amount of Ultraformer AOG (Hydrogen Gas) burned at the Desulfurizer is determined by using the graph in the file and an average Naptha flow for the month. This will give an average daily rate for the entire month. The fuel analysis and the special emission factor is the same as for the Hydrogen Gas at the Power Station. This is also method-5.

### Stacks #15

A monthly average is also used for the reformer furnaces. This is determined by subtracting the gas used at the desulfurizer and the hydrogen gas used at the power station from the amount of AOG produced and then determining a monthly average figure and dividing it equally among the three furnaces.

Fuel oil from tank 420 is also used in the reformer furnaces. This is assumed constant and is recorded as $1.4 \times 10^3$ gallons per day on each of the three furnaces. Method-3 is used and the amount is recorded as a daily figure.

## Asphalt Plant

### Furnace (Stack 17):

This is figured by assuming fuel is burned 50% of the time at 6800 cubic feet/hour. This number will always be recorded as 81.6 x $10^3$ft$^3$ per day. Gas burned here is refinery gas; same analysis as at power station, method-5.

### Fume Burner (Stack 23): SCC 30600999

Refinery gas is burned here also, at two different rates during the year which will be specified on the monthly data; either 62.4 x $10^3$ ft$^3$/day or 230.4 x $10^3$ ft$^3$/day. Method-5.

## South Flare (Stack 21): SCC 30600999

Until notified differently, this flare burns 15.5 x $10^3$ ft$^3$/day of Refinery Gas and emits 10.0 tons per day $SO_2$ every day.

For the straight $SO_2$ emission there is no fuel analysis, Method-8, units - TON.

## B-2 Flare (Stack 22): SCC30600999

This depends upon which processes are in operation, which will be specified in the data.

A-198 emits 9475 pounds $SO_2$ per day

A-202 emits 4300 pounds $SO_2$ per day

A-463 emits 5532 pounds $SO_2$ per day

A-464 emits 4820 pounds $SO_2$ per day

Depending upon what is in operation, the daily total is divided by 24 and the hourly emission in pounds is entered.

Some or all of these emissions will be eliminated if sufficient DEA is available to AMOCO.

## BOT Flare (Stack 24)

When the A-150 process is running, as indicated on the data sheets, this will have an emission of 2379.5 pounds per day $SO_2$.

This also may be eliminatad by having enough DEA.

## FLUID CRACKER (Stack 25): SCC 30600201

This is recorded directly as thousands of barrels per day from the data. There is no fuel analysis, method-5, units - BBL.

## Special Emission Factors

| | |
|---|---|
| Refinery Gas | F = 1.069 S |
| Hydrogen Gas | F = 1.069 S |
| Slop Oil | F = 144 S |
| Asphalt | F = 164 S |
| No. 5 PS AOG | F = 1.069 S |
| Fluid Crackers | F = 347.5 |

## CLARK OIL REFINERY (618) 254-7301

Illinois - 14, Madison Co. - 4680, Hartford - 9020, Plant - 05

Location: Int. 270 east, north on Ill. 3 to Hartford, right on Hawthorne

Personnel: Mr. Seward VanPetten - Manager, Construction - our contact

Data Acquisition: monthly by mail

Data Description: monthly totals of oil and gas consumption copies of any fuel analyses

Data Handling:

1) Using percentages on file, distribute total fuel consumption to each process heater and power house boiler. Fluid Crack thruput remains unchanged.

2) Determine an average fuel analysis for the month, unless there is a definite time period given with each fuel analysis.

3) On each coding form, record appropriate ID's, current fuel analysis, method-5 for gas, 3 for oil, pollutant - SOX, data units - CFT for gas, GAL for oil, time interval - D, appropriate julian dates, SCC number and action.

4) For Fluid Cracker there is no fuel analysis, method-3, units - BBL, time interval - D.

5) In data spaces, divide monthly figures for each unit by days in the month and record the number of days under R followed by the daily amount. For the fluid cracker record the number of days under R followed by the daily thruput.

6) Gas should be recorded as thousands of cubic feet, oil as thousands of gallons and fluid cracker thruput as thousands of barrels.

7) On each data card (card 5) indicate type of data and action.

Data Processing: For the oil usage and the fluid cracker thruput the entered figure will be used directly with AP-42 emission factors to determine emissions. For gas usage, a special emission factor will be entered separately and used with the entered data to determine emissions. F = 0.98 S.

GENERAL MOTORS ASSEMBLY (314) 679-5152

---

Missouri - 26, St. Louis City - 4280, St. Louis - 4280, Plant - 06

Location: 3809 N. Union Street

Personnel: Dick Dumont - Engineer - our contact

Data Acquisition: by mail, monthly, from the plant

Data Description: Steam charts from 4 boiler, coal analysis

Data Handling:

1) On each coding form, record appropriate ID's, current fuel analysis, method-3, pollutant-SØX, data units - LBS, time interval of entered data, appropriate julian date, efficiency, SCC number, and action-A. Data type-1.

2) In data spaces, record hourly thousands of pounds of steam produced. Readings are taken at the half hour, i.e. 7:30 for the 7-8 AM reading.

## HIGHLAND ELECTRIC AND LIGHT (618) 654-4101

Illinois - 14, Madison Co. - 4680, Highland - 3340, Plant - 22

Location: Int. 70 east, south on Ill. 143, cross U.S. 40, right after crossing R.R. tracks, right on 9th street

Personnel: Mr. Allen Schulte - plant superintendent - our contact
Mr. Oliver Bishop - city manager

Data Acquisition: pickup monthly from the plant

Data Description: Xerox of monthly log and daily log sheets

Data Handling:

1) On each coding form, record appropriate ID's, current coal analysis, method, pollutant, data units of measure, time interval of entered data, appropriate julian date, thermal efficiency, SCC number, and action.
2) In data spaces, record Kilowatt (KW) production every other hour and then repeat each number for the next hour.
3) On each data card (card 5) indicate type of data and action.
4) The sequence number will be entered just before coding forms are sent out for keypunching.

## MONSANTO - WGK - Sauget, Illinois (314) 621-4075

Illinois - 14, St. Clair Co. - 6900, Sauget - 9010, Plant - 06

**Location**: Monsanto Ave., Sauget, Illinois

**Personnel**: Clarrie Buckley - Environmental Specialist - our contact
Paul Hodges - Corporate Headquarters

**Data Acquisition**: by mail from the plant monthly

**Data Description**: Tabulated, hourly, steam rate from power house and hourly emission rate of $SO_2$ from a contact sulfuric acid plant.

**Data Handling**:

1) On each coding form, record appropriate ID's, method - 3 or 8, pollutant - S0X, data units - LB, time interval of entered data, appropriate julian date, SCC number and action. Data type - 1.

2) In data spaces, record hourly steam load or hourly $SO_2$ emissions.

MONSANTO - Sauget, Illinois (314) 621-4075

---

Illinois - 14. St. Clair Co. - 6900, Sauget - 9010, Plant - 06

Location: Monsanto Ave, Sauget, Illinois

Personnel: Clarrie Buckley - Environmental Specialist - our contact
Paul Hodges - Corporate Headquarters

Data Acquisition: by mail from the plant monthly

Data Description: Tabulated, hourly, mass emission rates of $SO_2$ from 6 boilers and a contact sulfuric acid plant.

Data Handling:

1) On each coding form, record appropriate ID's, method-8, pollutant-SOX, data units - LB, time interval of entered data, appropriate julian date, SCC number and action. Data type - 1.
2) In data spaces, record hourly emission values.

## MONSANTO - 1700 S. Second Street (314) 621-4000

Missouri - 26, St. Louis City - 4280, St. Louis - 4280, Plant - 23

Location: 1700 S. Second St., St. Louis

Personnel: Al Peterson - Environmental Specialist - our contact
Paul Hodges - Corporate Headquarters

Data Acquisition: by mail from the plant monthly

Data Description: Steam charts from K street boiler (coal) and Geyer St. Boilers (when using oil), daily ratio of high to low sulfur coal burned. The boilers on gas are included for heat inventory.

Data Handling:

1) On each coding form, record appropriate ID's, current fuel analysis, method-3, pollutant-SOX, data units - LBS, time interval of entered data, appropriate julian date, SCC number and action, and efficiency.

2) In data spaces, record hourly thousands of pounds of steam produced. Readings are taken at the half hour, i.e., 7:30 for the 7-8 am reading.

Charts are changed at 11:30 pm. Last hour of day is on next day's chart.

Data Processing:

1) The daily fuel analysis must be calculated from the high/low ratio and the current coal analysis.

## ILLINOIS POWER - Baldwin (618) 785-2294

Illinois - 14, Randolph Co - 6460, Baldwin - 9000, Plant 01

Location: South on Ill. 3 to Red Bud, continue straight on Ill. 154 to Baldwin, left on 5th Street

Personnel:
Mr. Kane - Plant Manager
Mr. Mason - Plant Engineer - our contact
Mr. Jim May - Our contact in Decatur

Data Acquisition: by mail, from Decatur, weekly. We supply stamped envelopes with return addresses.

Data Description: Xerox of daily computer log sheets, copy of monthly coal analyses.

Data Handling:

1) On each coding form, record appropriate ID's, current coal analysis, method, pollutant, data units of measure, time interval of entered data, appropriate julian date, SCC number and action.

2) In data spaces, record hourly coal usage, as is.

## UNION ELECTRIC (314) 621-2637

| | | | | |
|---|---|---|---|---|
| Labadie: | Missouri-26, | Franklin Co - 1680, | Labadie-5200, | Plant - 03 |
| Sioux : | Missouri-26, | St. Charles - 4160, | W. Alton, 5220, | Plant - 01 |
| Meramec: | Missouri-26, | St. Louis Co. - 4300, | | Plant - 10 |
| Venice: | Illinois-14, | Madison Co. - 6900, | Venice - 7760 | Plant - 03 |
| Cahokia: | Illinois-14, | St. Clair Co. 6900, | Sauget - 9010 | Plant - 14 |
| Ashley: | Missouri-26, | St. Louis City - 4280, | St. Louis - 4280, | Plant - 38 |

Location: Data from main office - 1901 Gratiot Street, St. Louis

Personnel: Gerald Smith - Environmental Manager
John Wooten - Engineer - our contact

Data Acquistiion: by mail from main office

Data Description: Computer printout for Meramec, xerox of UE generation summary for Venice, Sioux, and Labadie and Cahokia. Boiler hours for Cahokia.

Data Handling:

1) On each coding form, record appropriate ID's, current coal analysis, method, pollutant, data units of measure, time interval of entered data, appropriate julian date, thermal efficiency, SCC number, and action.

2) In data spaces, record megawatt (MW) production for each hour, as is, for Labadie, Sioux, and Meramec. For Venice, when the production is 95 MW or less, record as if #7 was only running and when more than 95 MW the production is equally split and recorded as noted on the data worksheet. When oil is burned at Venice, this is also noted on the data worksheet. Cahokia stack output is determined from plant output and boiler service charts.

STAG BREWERY (CARLING) (618) 234-1234

---

Illinois - 14, St. Clair County - 6900, Belleville - 0320, Plant - 01

Location: 1201 West E. Street, Belleville

Personnel: Don Hoageson - Chief Engineer, our contact

Data Acquisition: Steam charts from 2 boilers

Data Handling:

1) On each coding form, record appropriate ID's, current fuel analysis, method-3, pollutant-S0X, data units - LBS, time interval of entered data, appropriate julian date, efficiency, SCC number, and action - A. Data type - 1.

2) In data spaces, record hourly thousands of pounds of steam produced. Readings are taken at the half hour, i.e. 7:30 for the 7-8 am reading.

PVO INTERNATIONAL - 3400 N. Wharf St. (314) 621-4345

---

Missouri - 26, St. Louis City - 4280, Plant - 58

Location: Wharf St. at Angelrodt, St. Louis

Personnel: Don Mueller - Engineering manager - our contact

Data Acquisition: by mail, monthly, from the plant

Data Description: Steam charts from all 3 boilers.

Data Handling:

1) Convert chart readings from percent to steam output (thousands of pounds per hour)

2) On each coding form, record appropriate ID's, current fuel analysis, method-3, pollutant-SOX, data units - LBS, time interval of entered data, appropriate julian date, SCC number, efficiency, and action. Data type - 1.

3) In data spaces, record hourly thousands of pounds of steam produced. Readings are taken at the half-hour, i.e. 7:30 for the 7-8 am reading.

   Charts are changed at 7:30 am. First 8 hours of a day are on the previous day's chart.

# APPENDIX B

The following list identifies the point sources in the RAPS data base that have been source tested, resulting in point specific emission factors.

| State | County | Plant ID | Stack ID | SCC Code | Plant Name |
|---|---|---|---|---|---|
| 26 | 4300 | 02 | 08 | 1-02-006-01 | Chrysler Motors |
| 14 | 4680 | 13 | 04 | 3-05-014-01 | Owens-Illinois |
| 26 | 4300 | 01 | 01 | 3-05-007-05 | Alpha Cement |
| 26 | 2280 | 06 | 10 | 3-01-013-01 | USS Agri Chem |
| 14 | 4680 | 01 | 01 | 1-01-006-01 | Illinois Power-Wood River |
| 14 | 4680 | 01 | 01 | 1-01-005-01 | Illinois Power-Wood River |
| 14 | 4680 | 01 | 02 | 1-01-002-01 | Illinois Power-Wood River |
| 14 | 4680 | 22 | 03 | 1-01-002-08 | Highland Power |
| 14 | 6900 | 01 | 01 | 1-02-002-08 | Stag Brewery |
| 26 | 4280 | 06 | 01 | 1-02-002-02 | General Motors |
| 14 | 4680 | 04 | 64 | 3-06-002-01 | Amoco Refinery |

# APPENDIX C

The following three lists identify point sources in the RAPS data base for which actual process or fuel data have been gathered on an hourly, daily or monthly basis.

## MONTHLY DATA

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 26 | 4280 | 03 | ANHEUSER BUSCH INC | 06 | 39000630 |
| * | 26 | 4300 | 09 | N L INDUSTRIES | 03 | 10200601 |
| * |  |  |  |  | 04 | 10200601 |
| * |  |  |  |  | 05 | 10200401 |
| * |  |  |  |  | 10 | 39000699 |
| * |  |  |  |  | 11 | 39000699 |
| * |  |  |  |  | 13 | 39000699 |

## HOURLY DATA

```
                          PLANT                               STACK      SCC
   STATE       COUNTY      ID               PLANT               ID      CODES
 *  14          4680       01      ILLINOIS POWER CO            02     10100202

 *                                                              03     10100202
 *  14          4680       03      UNION ELECTRIC CO  VENICE    01     10100501

 *                                                              02     10100501
 *                                                              03     10100501
 *                                                              04     10100501
 *                                                              05     10100501
 *                                                              06     10100501
 *                                                              07     10100202
 *                                                              08     10100202
 *  14          4680       04       AMOCO OIL REFINERY          22     30600999

 *  14          4680       14       SHELL OIL CO                01     30600104

 *                                                              02     30600104
 *                                                              03     30600104
 *                                                              04     30600104
 *                                                              05     30600104
 *                                                              06     30600104
 *                                                              07     30600104
 *                                                              13     30600104
 *                                                              14     30600104
 *                                                              15     30600104
 *                                                              17     30600104
 *                                                              18     30600104
 *                                  19       30600104
 *                                                              21     30600104
 *                                                              22     30600104
 *                                                              24     30600104
 *                                                              30     30600104
 *                                                              31     30600104
 *                                                              33     30600104
```

(continued)

## HOURLY DATA (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 34 | 30600104 |
| * | | | | | 39 | 30600104 |
| * | | | | | 41 | 30600104 |
| * | | | | | 46 | 10200601 |
| * | | | | | | 10200601 |
| * | | | | | 48 | 10200601 |
| * | | | | | | 10200601 |
| * | | | | | 50 | 10200601 |
| * | | | | | 51 | 10200601 |
| * | | | | | 52 | 10200601 |
| * | | | | | 53 | 10200601 |
| * | | | | | 76 | 10200601 |
| * | | | | | 79 | 10200601 |
| * | 14 | 4680 | 22 | HIGHLAND ELECTRIC PLT | 01 | 10100208 |
| * | | | | | 03 | 10100208 |
| * | 14 | 6450 | 01 | ILLINOIS POWER CO | 01 | 10100203 |
| * | | | | | 02 | 10100203 |
| * | | | | | 03 | 10100202 |
| * | 14 | 6900 | 01 | CARLING/STAG BREWING CO | 01 | 10200205 |
| * | | | | | | 10200205 |
| * | 14 | 6900 | 06 | MONSANTO CO | 05 | 10200401 |
| * | | | | | | 10200601 |
| * | | | | | 06 | 10200401 |
| * | | | | | | 10200601 |
| * | | | | | 07 | 10200204 |
| * | | | | | 08 | 10200204 |
| * | | | | | 09 | 10200204 |
| * | | | | | 10 | 10200204 |
| * | | | | | 22 | 30199999 |

(continued)

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## HOURLY DATA (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 14 | 6900 | 14 | UNION ELECTRIC CAHOKIA M | 01 | 10100401 |
| * | | | | | 02 | 10100401 |
| * | | | | | 03 | 10100401 |
| * | | | | | 04 | 10100401 |
| * | | | | | 05 | 10100401 |
| * | | | | | 06 | 10100401 |
| * | 14 | 6900 | 38 | AMAX ZINC CO | 01 | 30102399 |
| * | 26 | 1680 | 03 | UNION ELECTRIC CO | 01 | 10100201 |
| * | | | | | 02 | 10100201 |
| * | | | | | 03 | 10100201 |
| * | | | | | | 10100201 |
| * | 26 | 2280 | 15 | UNION ELECTRIC | 01 | 10100201 |
| * | | | | | 02 | 10100201 |
| * | 26 | 4160 | 01 | UNION ELECTRIC CO SIOUX | 01 | 10100203 |
| * | | | | | 02 | 10100203 |
| * | 26 | 4260 | 03 | ANHEUSER BUSCH INC | 01 | 10200202 |
| * | | | | | | 10200202 |
| * | | | | | 02 | 10200202 |
| * | | | | | | 10200202 |
| * | | | | | | 10200601 |
| * | | | | | 03 | 10200202 |
| * | | | | | | 10200601 |
| * | | | | | 04 | 10200601 |
| * | | | | | 05 | 10200601 |

(continued)

## HOURLY DATA (continued)

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 26 | 4280 | 06 | GENERAL MOTORS ASSEMB | 01 | 10200202 |
| * |  |  |  |  |  | 10200208 |
| * |  |  |  |  |  | 10200209 |
| * |  |  |  |  | 101 | 10200202 |
| * |  |  |  |  |  | 10200208 |
| * |  |  |  |  |  | 10200209 |
| * | 26 | 4280 | 23 | MONSANTO CO | 02 | 10200602 |
| * |  |  |  |  | 03 | 10200602 |
| * |  |  |  |  | 04 | 10200502 |
| * |  |  |  |  |  | 10200602 |
| * |  |  |  |  | 05 | 10200502 |
| * |  |  |  |  |  | 10200602 |
| * |  |  |  |  | 06 | 10200209 |
| * | 26 | 4280 | 58 | PVO INTERNATIONAL | 01 | 10200205 |
| * |  |  |  |  |  | 10200602 |
| * |  |  |  |  | 02 | 10200205 |
| * |  |  |  |  | 03 | 10200205 |
| * |  |  |  |  |  | 10200602 |
| * | 26 | 4300 | 10 | UNION ELECTRIC CO MERAMEC | 01 | 10100201 |
| * |  |  |  |  | 02 | 10100201 |
| * |  |  |  |  | 03 | 10100201 |
| * |  |  |  |  | 04 | 10100201 |

# DAILY DATA

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 14 | 4680 | 01 | ILLINOIS POWER CO | 01 | 10100501 |
| * | | | | | | 10100501 |
| * | | | | | | 10100501 |
| * | | | | | | 10100601 |
| * | | | | | | 10100601 |
| * | | | | | | 10100601 |
| * | 14 | 4680 | 04 | AMOCO OIL REFINERY | 01 | 30600102 |
| * | | | | | | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | | 30600103 |
| * | | | | | | 30600108 |
| * | | | | | | 30600108 |
| * | | | | | | 30600109 |
| * | | | | | 03 | 30600102 |
| * | | | | | | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | | 30600103 |
| * | | | | | | 30600108 |
| * | | | | | | 30600108 |
| * | | | | | | 30600109 |
| * | | | | | 05 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | | 30600108 |
| * | | | | | | 30600109 |
| * | | | | | 06 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | | 30600108 |
| * | | | | | 07 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | | 30600107 |
| * | | | | | 09 | 30600103 |
| * | | | | | | 30600108 |

(continued)

## DAILY DATA (continued)

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * |  |  |  |  | 10 | 30600103 |
| * |  |  |  |  |  | 30600108 |
| * |  |  |  |  | 12 | 30600103 |
| * |  |  |  |  |  | 30600108 |
| * |  |  |  |  | 14 | 30600108 |
| * |  |  |  |  | 17 | 30600102 |
| * |  |  |  |  | 21 | 30600999 |
| * |  |  |  |  |  | 30699999 |
| * |  |  |  |  | 23 | 30600999 |
| * |  |  |  |  | 24 | 30600999 |
| * |  |  |  |  | 25 | 30600201 |
| * |  |  |  |  | 64 | 30600201 |
| * | 14 | 4680 | 05 | CLARK OIL CO | 01 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 02 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 03 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 04 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 05 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 06 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 08 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 09 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 10 | 30600102 |
| * |  |  |  |  |  | 30600103 |
| * |  |  |  |  | 11 | 30600102 |
| * |  |  |  |  |  | 30600103 |

(continued)

## DAILY DATA (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 12 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 13 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 14 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 15 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 16 | 30600102 |
| * | | | | | 17 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 18 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 19 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 20 | 30600201 |
| * | | | | | 51 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 52 | 30600102 |
| * | | | | | | 30600103 |
| * | | | | | 53 | 30600102 |
| * | | | | | | 30600103 |
| * | 14 | 4680 | 20 | ALTON BOX BOARD CO | 02 | 10200401 |
| * | | | | | 03 | 10200202 |
| * | | | | | | 10200601 |
| * | | | | | 04 | 10200202 |
| * | | | | | | 10200601 |
| * | 26 | 4280 | 38 | UNION ELECTRIC | 01 | 10100401 |

(continued)

## DAILY DATA (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 26 | 4300 | 09 | N L INDUSTRIES | 01 | 10200209 |
| * | | | | | 02 | 10200209 |
| * | | | | | 06 | 10200204 |
| * | | | | | 16 | 30102399 |
| * | | | | | 17 | 30102399 |
| * | | | | | 18 | 10200209 |

## ANNUAL DATA - WORKING PATTERNS

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 14 | 1440 | 01 | BUEHNE QUARRY CO | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | 14 | 1440 | 02 | MUNICIPAL POWER PLANT | 01 | 10100208 |
| * | 14 | 4680 | 04 | AMOCO OIL REFINERY | 63 | 40600126 |
| * | 14 | 4680 | 06 | RELIANCE QUARRY | 01 | 30502001 |
| * | | | | | 02 | 30502001 |
| * | 14 | 4680 | 07 | OLIN CORP. | 25 | 10200602 |
| * | | | | | 26 | 10200602 |
| * | | | | | 27 | 30400204 |
| * | | | | | 28 | 30400204 |
| * | 14 | 4680 | 08 | AMERICAN STEEL FOUNDRY | 03 | 10200402 |
| * | 14 | 4680 | 09 | GRANITE CITY STEEL | 07 | 30300803 |
| * | | | | | 08 | 30300803 |
| * | | | | | 09 | 30300803 |
| * | | | | | | 30300803 |
| * | | | | | 13 | 30300911 |
| * | | | | | | 30300911 |
| * | | | | | 14 | 30300920 |
| * | | | | | | 30300920 |
| * | | | | | | 30300920 |
| * | | | | | | 30300920 |
| * | | | | | | 30300920 |
| * | 14 | 4680 | 11 | N L INDUSTRIES | 01 | 30400403 |
| * | | | | | 02 | 30400403 |
| * | | | | | 03 | 10200603 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 04 | 10200603 |
| * | | | | | 05 | 10200603 |
| * | 14 | 4680 | 13 | OWENS-ILLINOIS INC. | 01 | 10200402 |
| * | | | | | | 10200402 |
| * | | | | | | 10200402 |
| * | | | | | | 10200602 |
| * | | | | | | 10200602 |
| * | | | | | | 10200602 |
| * | 14 | 4680 | 15 | MISSISSIPPI LIME | 01 | 30501601 |
| * | | | | | | 30501601 |
| * | | | | | | 30501601 |
| * | | | | | 02 | 30501602 |
| * | | | | | | 30501602 |
| * | 14 | 4680 | 16 | LACLEDE STEEL CO | 01 | 10200401 |
| * | | | | | | 10200601 |
| * | | | | | 06 | 39000499 |
| * | | | | | 08 | 39000499 |
| * | 14 | 4680 | 17 | GRANITE CITY ARMY DEPOT | 02 | 10300402 |
| * | | | | | | 10300502 |
| * | | | | | 03 | 10300402 |
| * | | | | | | 10300502 |
| * | 14 | 4680 | 23 | FINLEY PLATING CO | 01 | 10200603 |
| * | 14 | 4680 | 27 | CONSOLIDATED ALUMINUM CO | 02 | 10200602 |
| * | 14 | 4680 | 31 | MOSS AMERICAN INC | 01 | 10200502 |
| * | 14 | 4680 | 36 | REILLY TAR & CHEM | 01 | 10200402 |

(continued)

# ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | | 10200602 |
| * | | | | | 02 | 10200402 |
| * | | | | | | 10200602 |
| * | | | | | 03 | 49099999 |
| * | 14 | 5180 | 01 | COLUMBIA QUARRY PLT #3 | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | | | | | 05 | 39000609 |
| * | | | | | 06 | 39000609 |
| * | 14 | 6460 | 04 | MENARD BR. ILL. PEN. | 01 | 10300209 |
| * | | | | | | 10300602 |
| * | 14 | 6460 | 05 | CHESTER QUARRY | 01 | 20100301 |
| * | | | | | 02 | 30502001 |
| * | | | | | 03 | 30502002 |
| * | | | | | 04 | 30502006 |
| * | 14 | 6460 | 06 | STOTZ QUARRY | 01 | 30502001 |
| * | | | | | | 30502002 |
| * | | | | | 02 | 30502006 |
| * | | | | | 03 | 30502007 |
| * | | | | | 04 | 20200401 |
| * | 14 | 6900 | 04 | COLUMBIA QUARRY PLT 9 | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | 14 | 6900 | 08 | RICHLAND FOUNDRY CO | 01 | 30400301 |
| * | | | | | | 39000505 |
| * | 14 | 6900 | 10 | STOLLE QUARRY | 01 | 30502001 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502003 |
| * | | | | | 04 | 30502006 |
| * | 14 | 6900 | 11 | E ST LOUIS STONE | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502003 |
| * | | | | | 04 | 30502004 |
| * | | | | | 05 | 30502005 |
| * | 14 | 6900 | 12 | COLUMBIA QUARRY PLT #1 | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | 14 | 6900 | 15 | LOCKE STOVE CO | 01 | 40200101 |
| * | | | | | | 40200301 |
| * | | | | | | 40200801 |
| * | 14 | 6900 | 16 | MORRIS PAINT & VARNISH | 01 | 30101401 |
| * | 14 | 6900 | 17 | NUTRENA MILLS | 03 | 30200501 |
| * | 14 | 6900 | 18 | R FOX LTD | 01 | 10200212 |
| * | 14 | 6900 | 19 | HUNTER PACKING CO | 01 | 10200502 |
| * | | | | | | 10200602 |
| * | | | | | 02 | 10200502 |
| * | | | | | | 10200602 |
| * | | | | | 03 | 39000631 |
| * | 14 | 6900 | 20 | CONTINENTAL GRAIN CO | 01 | 30200501 |
| * | | | | | 02 | 30200504 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 14 | 6900 | 24 | AUTOCRAT CORP | 01 | 10200213 |
| * | 14 | 6900 | 25 | CERRO COPPER PRODUCTS | 01 | 10200603 |
| * | | | | | 02 | 10200603 |
| * | | | | | 03 | 10200603 |
| * | | | | | 05 | 39000605 |
| * | | | | | 06 | 39000605 |
| * | | | | | 07 | 39000605 |
| * | | | | | 09 | 39000605 |
| * | | | | | 10 | 39000605 |
| * | | | | | 12 | 39000605 |
| * | | | | | 13 | 39000605 |
| * | | | | | 14 | 39000605 |
| * | 14 | 6900 | 26 | CERTAIN-TEED | 01 | 10200502 |
| * | 14 | 6900 | 35 | MODERN FOUNDRY | 01 | 30400301 |
| * | 14 | 6900 | 36 | EMPIRE STOVE CO | 01 | 40200501 |
| * | | | | | | 40200801 |
| * | | | | | 02 | 40200901 |
| * | 14 | 7920 | 01 | COVINGTON STONE CO | 01 | 20200401 |
| * | | | | | 02 | 30502001 |
| * | | | | | 03 | 30502006 |
| * | | | | | 04 | 30502007 |
| * | | | | | 05 | 30502002 |
| * | 14 | 7920 | 02 | PITTS QUARRY | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | 26 | 4160 | 06 | PENNSYLVANIA GLASS SAND | 01 | 30504034 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * |  |  |  |  | 02 | 30504033 |
| * |  |  |  |  |  | 30504033 |
| * |  |  |  |  |  | 39000599 |
| * |  |  |  |  |  | 39000599 |
| * |  |  |  |  |  | 39001099 |
| * | 26 | 4160 | 08 | ST CHARLES QUARRY | 01 | 30502001 |
| * |  |  |  |  | 03 | 30502006 |
| * | 26 | 4160 | 09 | JOERLING BROS QUARRY #1 | 01 | 30502001 |
| * |  |  |  |  | 02 | 30502002 |
| * |  |  |  |  | 03 | 30502004 |
| * | 26 | 4160 | 11 | DIDION & SONS FOUNDRY | 01 | 30400303 |
| * | 26 | 4160 | 15 | DEFIANCE QUARRY | 01 | 30502001 |
| * |  |  |  |  | 02 | 30502002 |
| * |  |  |  |  | 03 | 30502006 |
| * |  |  |  |  | 04 | 30502007 |
| * | 26 | 4160 | 16 | JOERLING BROS QUARRY #2 | 01 | 30502001 |
| * |  |  |  |  | 02 | 30502002 |
| * |  |  |  |  | 03 | 30502006 |
| * | 26 | 4280 | 01 | AMERICAN CAN CO | 01 | 39000699 |
| * |  |  |  |  |  | 40200801 |
| * | 26 | 4280 | 02 | AMCAR DIV (AMERICAN CAR) | 02 | 40299999 |
| * | 26 | 4280 | 06 | GENERAL MOTORS ASSEMBLY | 02 | 40200501 |
| * |  |  |  |  |  | 40200801 |
| * | 26 | 4280 | 09 | CROWN CORK & SEAL | 01 | 40200801 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 26 | 4280 | 24 | MUNICIPAL INCINERATOR N. | 01 | 50100101 |
| * | | | | | 02 | 50100101 |
| * | 26 | 4280 | 25 | MUNICIPAL INCINERATOR S. | 01 | 50100101 |
| * | | | | | 02 | 50100101 |
| * | 26 | 4280 | 57 | PROCTER AND GAMBLE | 02 | 10200602 |
| * | 26 | 4300 | 02 | CHRYSLER ASSEMBLY PLANT | 01 | 40200601 |
| * | | | | | | 40200801 |
| * | | | | | 03 | 40200101 |
| * | | | | | 04 | 40200901 |
| * | | | | | 05 | 40200401 |
| * | 26 | 4300 | 03 | CONTINENTAL CAN CO | 01 | 10200402 |
| * | 26 | 4300 | 04 | EMERSON ELECTRIC | 01 | 10200402 |
| * | | | | | | 10200602 |
| * | 26 | 4300 | 05 | FORD ASSEMBLY PLANT | 01 | 40200501 |
| * | | | | | | 40200601 |
| * | | | | | | 40200801 |
| * | | | | | | 40200901 |
| * | 26 | 4300 | 06 | LIANCO CONTAINER | 01 | 40200801 |
| * | | | | | 02 | 40200801 |
| * | 26 | 4300 | 20 | RAMSEY CORP | 01 | 40100205 |
| * | | | | | 02 | 40100202 |
| * | 26 | 4300 | 21 | PENNA GLASS Z SAND CORP | 01 | 30502501 |
| * | | | | | 02 | 39099998 |

(continued)

## ANNUAL DATA - WORKING PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 26 | 4300 | 31 | CHRYSLER TRUCK ASSEMBLY | 01 | 39000699 |
| * | | | | | | 40200501 |
| * | | | | | | 40200601 |
| * | | | | | | 40200801 |
| * | | | | | | 40200901 |
| * | 26 | 4300 | 33 | BUSSEN QUARRY | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |

# APPENDIX E

The following list identifies the point sources for which no temporal distribution is recorded. This includes both sources for which no temporal data were available (for example, storage tanks) as well as those which were known to have a uniform annual distribution (for example, points operating uniformly 24 hours a day, 365 days a year).

## ANNUAL DATA - NO PATTERNS

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | 14 | 1440 | 01 | BUEHNE QUARRY CO | 04 | 30502007 |
| * | 14 | 1440 | 02 | MUNICIPAL POWER PLANT | 01 | 20100101 |
| * | | | | | | 20100201 |
| * | 14 | 1440 | 04 | CARLYLE MUNICIPAL POWER | 01 | 20100202 |
| * | | | | | | 20100301 |
| * | 14 | 4680 | 02 | ILLINOIS POWER STALLING | 01 | 10100501 |
| * | | | | | 02 | 10100501 |
| * | | | | | 03 | 10100501 |
| * | | | | | 04 | 10100501 |
| * | 14 | 4680 | 04 | AMOCO OIL REFINERY | 26 | 30600401 |
| * | | | | | 28 | 30600701 |
| * | | | | | 29 | 30600801 |
| * | | | | | 30 | 30600802 |
| * | | | | | 31 | 30600803 |
| * | | | | | 32 | 30600804 |
| * | | | | | 34 | 40300201 |
| * | | | | | 35 | 40300201 |
| * | | | | | 36 | 40300201 |
| * | | | | | 37 | 40300201 |
| * | | | | | 38 | 40300201 |
| * | | | | | 39 | 40300201 |
| * | | | | | 40 | 40300203 |
| * | | | | | 41 | 40300203 |
| * | | | | | 42 | 40300201 |
| * | | | | | 43 | 40300201 |
| * | | | | | 44 | 40300201 |
| * | | | | | 45 | 40300201 |
| * | | | | | 46 | 40300201 |
| * | | | | | 47 | 40300201 |

(continued)

ANNUAL DATA - NO PATTERNS (continued)

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * |  |  |  |  | 48 | 40300201 |
| * |  |  |  |  | 49 | 40300201 |
| * |  |  |  |  | 50 | 40300201 |
| * |  |  |  |  | 51 | 40300201 |
| * |  |  |  |  | 52 | 40300201 |
| * |  |  |  |  | 53 | 40300201 |
| * |  |  |  |  | 54 | 40300201 |
| * |  |  |  |  | 55 | 40300156 |
| * |  |  |  |  | 56 | 40300156 |
| * |  |  |  |  | 57 | 40300156 |
| * |  |  |  |  | 58 | 40300156 |
| * |  |  |  |  | 59 | 40300156 |
| * |  |  |  |  | 60 | 40300203 |
| * |  |  |  |  | 61 | 40300203 |
| * |  |  |  |  | 62 | 40300203 |
| * |  |  |  |  | 65 | 40600201 |
| * | 14 | 4680 | 05 | CLARK OIL CO | 21 | 30600401 |
| * |  |  |  |  | 23 | 30600701 |
| * |  |  |  |  | 24 | 30600801 |
| * |  |  |  |  | 25 | 30600802 |
| * |  |  |  |  | 26 | 30600803 |
| * |  |  |  |  | 27 | 30600804 |
| * |  |  |  |  | 29 | 40300201 |
| * |  |  |  |  | 30 | 40300201 |
| * |  |  |  |  | 31 | 40300201 |
| * |  |  |  |  | 32 | 40300201 |
| * |  |  |  |  | 33 | 40300201 |
| * |  |  |  |  | 34 | 40300201 |
| * |  |  |  |  | 35 | 40300201 |
| * |  |  |  |  | 36 | 40300201 |
| * |  |  |  |  | 37 | 40300203 |
| * |  |  |  |  | 38 | 40300203 |

(continued)

## ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 39 | 40300203 |
| * | | | | | 40 | 40300201 |
| * | | | | | 41 | 40300201 |
| * | | | | | 42 | 40300203 |
| * | | | | | 43 | 40300207 |
| * | | | | | 44 | 40600126 |
| * | 14 | 4680 | 06 | RELIANCE QUARRY | 03 | 30502007 |
| * | 14 | 4680 | 08 | AMERICAN STEEL FOUNDRY | 01 | 30400701 |
| * | | | | | 02 | 30400701 |
| * | | | | | 03 | 10200602 |
| * | 14 | 4680 | 09 | GRANITE CITY STEEL | 01 | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300303 |
| * | | | | | | 30300303 |
| * | | | | | | 30300303 |
| * | | | | | | 30300303 |
| * | | | | | | 30300304 |
| * | | | | | | 30300399 |
| * | | | | | | 30300399 |
| * | | | | | | 30300399 |
| * | | | | | 02 | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300302 |
| * | | | | | | 30300303 |
| * | | | | | | 30300303 |
| * | | | | | | 30300303 |

(continued)

ANNUAL DATA - NO PATTERNS (continued)

| STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|
| * | | | | | 30300304 |
| * | | | | | 30300399 |
| * | | | | | 30300399 |
| * | | | | | 30300399 |
| * | | | | 03 | 30300302 |
| * | | | | | 30300302 |
| * | | | | | 30300302 |
| * | | | | | 30300302 |
| * | | | | | 30300302 |
| * | | | | | 30300303 |
| * | | | | | 30300303 |
| * | | | | | 30300303 |
| * | | | | | 30300304 |
| * | | | | | 30300399 |
| * | | | | | 30300399 |
| * | | | | | 30300399 |
| * | | | | 05 | 30300802 |
| * | | | | 06 | 30300802 |
| * | | | | 10 | 30300903 |
| * | | | | | 30300903 |
| * | | | | 19 | 10299997 |
| * | | | | | 10299997 |
| * | | | | | 10299997 |
| * | | | | 20 | 10299997 |
| * | | | | | 10299997 |
| * | | | | | 10299997 |
| * | | | | 21 | 10299998 |
| * | | | | | 10299998 |
| * | | | | | 10299998 |
| * | | | | 22 | 10299997 |
| * | | | | | 10299997 |
| * | | | | | 10299997 |
| * | | | | 23 | 10299997 |

(continued)

ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | | 10299997 |
| * | | | | | | 10299997 |
| * | 14 | 4680 | 12 | NESTLE CO. INC. | 01 | 10200402 |
| * | | | | | | 10200602 |
| * | | | | | 02 | 10200402 |
| * | | | | | | 10200602 |
| * | | | | | 03 | 10200402 |
| * | | | | | | 10200602 |
| * | | | | | 04 | 10200402 |
| * | | | | | | 10200602 |
| * | 14 | 4680 | 13 | OWENS-ILLINOIS INC. | 04 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 05 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 06 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 07 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 08 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 09 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 10 | 39000408 |
| * | | | | | | 39000608 |
| * | | | | | 11 | 39000408 |
| * | | | | | | 39000608 |
| * | 14 | 4680 | 14 | SHELL OIL CO | 57 | 30600401 |
| * | | | | | 59 | 30600701 |
| * | | | | | 60 | 30600801 |
| * | | | | | 61 | 30600802 |
| * | | | | | 62 | 30600803 |

(continued)

## ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 63 | 30600804 |
| * | | | | | 64 | 30600805 |
| * | | | | | 65 | 40300201 |
| * | | | | | 66 | 40300201 |
| * | | | | | 67 | 40300201 |
| * | | | | | 68 | 40300201 |
| * | | | | | 69 | 40300201 |
| * | | | | | 70 | 40300203 |
| * | | | | | 71 | 40300201 |
| * | | | | | 72 | 40300201 |
| * | | | | | 73 | 40300201 |
| * | | | | | 74 | 40300201 |
| * | | | | | 75 | 40300201 |
| * | | | | | 76 | 40300201 |
| * | 14 | 4680 | 16 | LACLEDE STEEL CO | 02 | 10200401 |
| * | | | | | | 10200601 |
| * | | | | | 03 | 30300905 |
| * | | | | | 04 | 30300905 |
| * | | | | | 06 | 39000699 |
| * | | | | | 08 | 39000699 |
| * | | | | | 11 | 39000699 |
| * | 14 | 4680 | 21 | DUNCAN FOUNDRY | 01 | 10200502 |
| * | | | | | 02 | 10200502 |
| * | | | | | | 10200602 |
| * | 14 | 4680 | 32 | ANILIN CO OF ILLINOIS | 01 | 30199999 |
| * | 14 | 4680 | 33 | ST JOSEPHS HOSPITAL | 01 | 10300213 |
| * | | | | | | 10300213 |
| * | 14 | 4680 | 37 | A O SMITH | 01 | 10200602 |
| * | | | | | 05 | 40200101 |

## ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | | 40200801 |
| * | 14 | 5180 | 01 | COLUMBIA QUARRY PLT #3 | 04 | 30502007 |
| * | 14 | 6460 | 04 | MENARD BR. ILL. PEN. | 01 | 10300209 |
| * | 14 | 6460 | 05 | CHESTER QUARRY | 05 | 30502007 |
| * | 14 | 6900 | 02 | SWIFT & CO NATIONAL CITY | 01 | 10200401 |
| * | | | | | | 10200401 |
| * | | | | | | 10200601 |
| * | | | | | | 10200601 |
| * | 14 | 6900 | 03 | PHILLIPS PETROLEUM | 02 | 40600126 |
| * | | | | | 03 | 40300201 |
| * | 14 | 6900 | 04 | COLUMBIA QUARRY PLT 9 | 04 | 30502007 |
| * | 14 | 6900 | 05 | MOBIL OIL CORPORATION | 01 | 40300201 |
| * | | | | | 02 | 40600126 |
| * | | | | | 03 | 40600130 |
| * | | | | | 04 | 40600201 |
| * | | | | | 05 | 40600205 |
| * | 14 | 6900 | 06 | MONSANTO CO | 02 | 30199999 |
| * | | | | | 04 | 30199999 |
| * | | | | | 14 | 30102699 |
| * | | | | | 15 | 30199999 |
| * | | | | | 16 | 30199999 |
| * | | | | | 17 | 30199999 |
| * | | | | | 25 | 30199999 |
| * | 14 | 6900 | 07 | SCOTT AIR FORCE BASE | 01 | 10300402 |
| * | | | | | 02 | 10300402 |

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## ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 03 | 10300402 |
| * | | | | | 04 | 10300402 |
| * | 14 | 6900 | 10 | STOLLE QUARRY | 05 | 30502007 |
| * | 14 | 6900 | 11 | E ST LOUIS STONE | 06 | 30502007 |
| * | 14 | 6900 | 12 | COLUMBIA QUARRY PLT #1 | 04 | 30502007 |
| * | 14 | 6900 | 13 | MASCOUTAH CITY POWER | 01 | 10100208 |
| * | | | | | | 10100502 |
| * | | | | | | 10100602 |
| * | | | | | 02 | 10100208 |
| * | | | | | | 10100502 |
| * | | | | | | 10100602 |
| * | 14 | 6900 | 21 | ST.ELIZABETHS HOSPITAL | 01 | 10300402 |
| * | 14 | 6900 | 26 | CERTAIN-TEED | 01 | 10200602 |
| * | 14 | 6900 | 27 | OBEAR NESTER GLASS | 01 | 10200602 |
| * | | | | | 09 | 30501401 |
| * | | | | | | 39000608 |
| * | | | | | 10 | 30501401 |
| * | | | | | | 39000608 |
| * | | | | | 11 | 30501401 |
| * | | | | | | 39000608 |
| * | 14 | 6900 | 28 | CENTREVILLE TWP HOSPITAL | 01 | 10300401 |
| * | 14 | 6900 | 34 | ALLIED CHEMICAL CORP | 01 | 10200602 |
| * | | | | | 02 | 30300101 |
| * | 14 | 6900 | 39 | EDWIN COOPER INC. | 01 | 30199999 |
| * | | | | | 02 | 30199999 |

(continued)

ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 03 | 30199999 |
| * | 14 | 7920 | 02 | PITTS QUARRY | 04 | 30502007 |
| * | 26 | 2280 | 01 | P.P.G. GLASS | 01 | 10200601 |
| * | 26 | 2280 | 02 | RIVER CEMENT CO | 01 | 30500699 |
| * | | | | | 02 | 30500605 |
| * | | | | | | 30500605 |
| * | 26 | 2280 | 03 | ST JO LEAD CO | 01 | 30301001 |
| * | | | | | | 30301001 |
| * | | | | | | 30400403 |
| * | | | | | | 30400403 |
| * | 26 | 2280 | 06 | USS AGRI-CHEM | 07 | 30102702 |
| * | | | | | 08 | 10200402 |
| * | | | | | 10 | 30101301 |
| * | 26 | 4160 | 08 | ST CHARLES QUARRY | 02 | 30502002 |
| * | | | | | 04 | 30502007 |
| * | 26 | 4160 | 09 | JOERLING BROS QUARRY #1 | 04 | 30502007 |
| * | 26 | 4160 | 16 | JOERLING BROS QUARRY #2 | 04 | 30502007 |
| * | 26 | 4160 | 21 | WILLIAMS PIPE LINE | 01 | 40300201 |
| * | | | | | | 40600126 |
| * | 26 | 4280 | 04 | APEX OIL CO | 01 | 40300107 |
| * | 26 | 4280 | 12 | GREAT LAKES CARBON | 01 | 30300301 |
| * | | | | | 02 | 30300301 |

(continued)

ANNUAL DATA - NO PATTERNS (continued)

|  | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * |  |  |  |  | 03 | 10200708 |
| * | 26 | 4280 | 13 | MISSOURI TERMINAL | 01 | 40300201 |
| * |  |  |  |  |  | 40600126 |
| * | 26 | 4280 | 15 | INDEPENDENT PETRO CHEM | 01 | 40300201 |
| * |  |  |  |  |  | 40600126 |
| * | 26 | 4280 | 16 | J.D.STREET & CO. | 01 | 40300201 |
| * |  |  |  |  |  | 40600126 |
| * |  |  |  |  |  | 40600201 |
| * | 26 | 4280 | 17 | MALLINCKRODT CHEM | 01 | 10200401 |
| * |  |  |  |  |  | 10200601 |
| * |  |  |  |  | 02 | 30199999 |
| * |  |  |  |  | 03 | 30199999 |
| * |  |  |  |  | 04 | 10200204 |
| * |  |  |  |  | 05 | 10200401 |
| * |  |  |  |  |  | 10200601 |
| * | 26 | 4280 | 18 | MARTIN OIL | 01 | 40300107 |
| * |  |  |  |  |  | 40300201 |
| * |  |  |  |  |  | 40600126 |
| * | 26 | 4280 | 22 | SUNOCO FORMERLY MONARK | 01 | 40300107 |
| * | 26 | 4280 | 23 | MONSANTO CO | 01 | 30199999 |
| * |  |  |  |  |  | 30199999 |
| * | 26 | 4280 | 34 | PAUL D. HARTOG INC. | 01 | 40300201 |
| * |  |  |  |  |  | 40600126 |
| * | 26 | 4280 | 35 | SHELL OIL CO | 01 | 40300101 |
| * |  |  |  |  |  | 40300103 |

(continued)

## ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | | 40300201 |
| * | | | | | | 40600126 |
| * | 26 | 4280 | 36 | TEXACO INC | 01 | 40300201 |
| * | | | | | | 40600126 |
| * | | | | | | 40600201 |
| * | 26 | 4280 | 40 | WASH. UNIV. EUCLID PWR P | 01 | 10300209 |
| * | | | | | | 10300602 |
| * | 26 | 4280 | 56 | VA HOSPITAL   COCHRAN | 01 | 10300401 |
| * | | | | | | 10300601 |
| * | 26 | 4280 | 59 | BANNER IRON WORKS | 01 | 30400301 |
| * | 26 | 4280 | 60 | GREEN FOUNDRY DIV BANNER | 01 | 30400301 |
| * | 26 | 4300 | 01 | ALPHA PORTLAND CEMENT | 01 | 30500705 |
| * | | | | | | 39000201 |
| * | 26 | 4300 | 02 | CHRYSLER ASSEMBLY  PLANT | 08 | 10200601 |
| * | | | | | 09 | 10200601 |
| * | 26 | 4300 | 07 | MCDONNELL DOUGLAS CORP | 01 | 10200601 |
| * | | | | | 02 | 40200101 |
| * | | | | | | 40200401 |
| * | | | | | | 40200501 |
| * | | | | | | 40200601 |
| * | | | | | | 40200901 |
| * | | | | | 04 | 10200602 |
| * | | | | | 05 | 10200602 |
| * | | | | | 06 | 10200602 |
| * | | | | | 07 | 10200602 |

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ANNUAL DATA - NO PATTERNS (continued)

| | STATE | COUNTY | PLANT ID | PLANT | STACK ID | SCC CODES |
|---|---|---|---|---|---|---|
| * | | | | | 08 | 10200602 |
| * | | | | | 09 | 10200602 |
| * | | | | | 10 | 10200602 |
| * | | | | | 11 | 10200602 |
| * | | | | | 12 | 10200602 |
| * | | | | | 13 | 10200602 |
| * | | | | | 14 | 10200602 |
| * | 26 | 4300 | 08 | MISSOURI PORTLAND CEMENT | 01 | 30500705 |
| * | | | | | | 39000201 |
| * | 26 | 4300 | 14 | VA HOSPITAL JEFF BARRACK | 01 | 10300502 |
| * | | | | | | 10300602 |
| * | 26 | 4300 | 16 | WASH. UNIV. CAMPUS PWR. | 01 | 10300209 |
| * | | | | | | 10300602 |
| * | 26 | 4300 | 29 | SUNOCO | 01 | 40300101 |
| * | | | | | | 40300103 |
| * | | | | | | 40300107 |
| * | | | | | | 40300152 |
| * | 26 | 4300 | 30 | TRIANGLE REFINERIES INC | 01 | 40300201 |
| * | | | | | | 40600126 |
| * | 26 | 4300 | 32 | ANTIRE QUARRY | 01 | 30502001 |
| * | | | | | 02 | 30502002 |
| * | | | | | 03 | 30502006 |
| * | | | | | 04 | 30502007 |
| * | 26 | 4300 | 33 | BUSSEN QUARRY | 04 | 30502007 |